Essays on International Capital Flows, Currency Crises and Exchange Rate Regimes

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Contents

Chapter 1

Introduction

1.1 Background and motivation

In the wake of the recent global financial turmoil, the subject of financial crises has come to the forefront of academic and policy discussions. Research on the causes of financial crises is booming (see Claessens et al., 2010; Rose and Spiegel, 2011 for overviews). One feature of the recent crisis is that it is widely spread and is characterized by huge and volatile capital flows (Milesi-Ferretti and Tille, 2011). A second feature is that the crisis occurred in countries with different exchange rate regimes (Frankel and Saravelos, 2012).

Chinese capital flows received much attention recently as well. On the one hand, capital flows from China contributed to the United States' ability to borrow cheaply abroad and thereby to finance its unsustainable external imbalance (Obstfeld and Rogoff, 2009; Borio and Disyatat, 2011; Bertaut et al., 2012). On the other hand, the increase of capital flows to China is widely considered to have generated financial instability in China (Glick and Hutchison, 2009; Prasad, et. al., 2005). Given China's status as the largest emerging economy, identifying the determinants of China's capital flows is of considerable interest. In this respect, a distinction is made between short-term and long-term capital flows (Claessens et al., 1995). The short-term capital flows are deemed speculative and reversible, i.e. they are "hot money" flows. The long-term capital flows are deemed reversible only when the fundamentals change, i.e. they are "cold money" flows. The hot money flows usually are explained on the basis of the current accounts of balance of payments or foreign direct investments. We will specifically pay attention to the Chinese hot money flows.

Sudden stops have become one of the characteristics of several financial crises in recent decades (Calvo, 1998; Mendoza, 2000). A sudden stop is an episode with a sharp contraction in international capital inflows (Calvo et al., 2004). An important issue that has attracted less attention is the joint occurrence of sudden stops and currency crises as, for example, in Argentina in 1980 and in Mexico in 1981. There

are also situations when sudden stops do not occur jointly with currency crises, such as in Sri Lanka in 2000 and Jordan in 1991. Since output declines are higher when both crises occur simultaneously (Efremidze et al., 2011), it is crucial to distinguish the precursors of these two types of crisis.

One controversial issue in international economics is the probability of currency crises under different exchange rate regimes (Bubula and Ötker-Robe, 2003; Rogoff et al., 2004). Frankel (1999) poses that no single currency regime is right for all countries or at all times. Every exchange regime is fragile and prone to crisis in some aspects (Eichengreen and Hausmann, 1999). Thus, the focus should not be on "which exchange regime is most prone to currency crises?" but "under what circumstances are economies with different exchange rate regimes are more prone to crisis?"

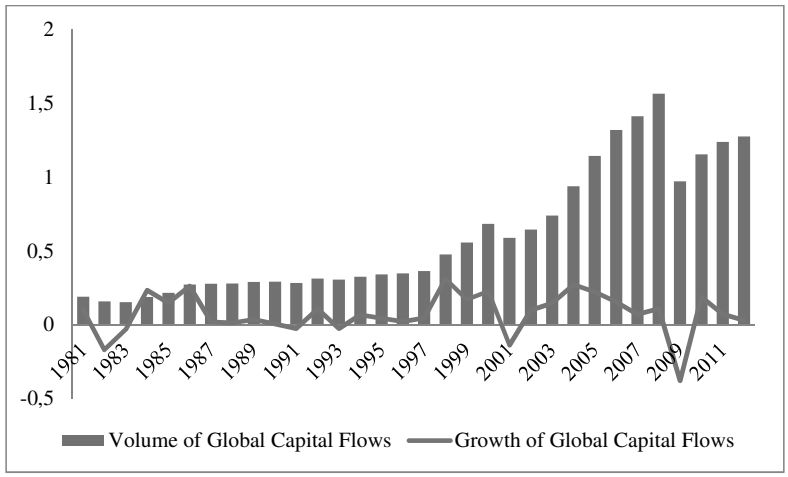
Up to now, only a few studies have examined the relationship between the spot exchange rate and the forward exchange rate during crisis periods; especially crises in emerging markets have not been thoroughly studied (the study by Frankel and Poonawala (2010) being an exception). China offers a very interesting case not only because it is the largest emerging economy but also because there are differences in the exchange rate regime even after its currency reform in 2005.

In this thesis, I will present research about international capital flows, currency crises and exchange rate regimes, and will in particular focus on the case of China.

1.2 International capital flows

It is widely accepted that international capital flows played an important role in the emergence of the US housing bubble and the global financial crisis that followed the bursting of that bubble (see e.g. Bertaut et al., 2012). The crisis had been preceded for many years by a widening of the global current account imbalances. The underlying capital flows to finance these imbalances would ultimately require a revaluation of currencies (Fratzscher, 2009; Lane and Milesi-Ferretti. 2012). Figure 1.1 shows that global net capital flows were 1.56 trillion US Dollars in 2008, which is about 3 times their (nominal) value compared to ten years before. In 2009, it suddenly dropped to 0.97 trillion US Dollars. After three years of adjustment, net capital flows in 2012 amounted to 1.27 trillion US Dollars.

Figure 1.1 Volume and growth of global net capital flows



Note: The unit of the volume of global capital flow is trillion US Dollars. The unit of the growth of global capital flows is percent. Source: World Economic Outlook Database April 2013.

Figure 1.1 shows that there are three years with a negative growth rate of global net capital flows since 1980 (1982, 2001 and 2009). In all three years financial crises occurred. In the early 1980s several Latin American countries, notably Brazil, Mexico and Argentina, had a deep financial crisis. In 2001, the Dot-com bubble bursted with a world-wide impact. The recent global financial crisis is considered by many scholars (e.g. Reinhart, 2012) to be the worst financial crisis since the Great Depression of the 1930s. After Lehman collapsed in September 2008, investors all over the world repatriated foreign investments, which resulted in a massive retrenchment of capital flows. After 2009, when central banks around the globe started to flood financial markets with liquidity, international capital flows revived quickly (see Figure 1.1). Bertaut et al. (2012) present a picture of how capital flows contributed to the financial crisis. Notably if the composition of capital inflows is skewed toward non-FDI and non-trade flows, such as bank lending and portfolio flows, capital flows contribute to instability since these investments are more likely to be reversed in the event of a crisis (Wei, 2006; Levchenko and Mauro 2007). A large literature analyzes the drivers of international capital flows (Fratzscher, 2012).

This dissertation studies net hot money flows in China using four alternative measures of hot money. Hot money flows are defined as capital flows that are not

related to the trade balance or foreign direct investments (Tung and Baker, 2004; Martin and Morrison, 2008; Guo and Huang, 2010a). Net hot money is the difference between capital inflows and capital outflows. While Chinese hot money flows have attracted significant attention (for example, Guo and Huang, 2010a and Shi and Xiao, 2011), the influence of structural reforms, new regulations and the financial crisis on the determinants of hot money flows has not been examined. Yet, understanding the dynamic behavior of hot money flows seems crucial for policy makers, especially given that hot money flows have become very volatile and are possibly driven by different factors in different periods. For example, foreign agents are allowed to invest in the Chinese stock market since the introduction of the qualified foreign institutional investors (QFII) system, which may strengthen the association between hot money and stock market developments (Ma and McCauley, 2007). Another example is the launch of regulations restricting foreign investment in the real estate market. These regulations may reduce the association between hot money and real estate market developments (He et al., 2011). Furthermore, financial crises are associated with more volatility in net hot money inflows (Milesi-Ferretti and Tille, 2011). But are these volatilities due to internal factors, such as developments at the stock market, the real estate market or the foreign exchange market, or external factors, such as interest rate differentials vis-à-vis the US and the Chicago Board Options Exchange Market Volatility Index (VIX) or both? In addition, are the results sensitive to the measurement of hot money?

Over the last three decades, both advanced and less advanced economies experienced boom-bust cycles in international capital flows. In the past, some less advanced economies (e.g. Chile and Argentina) suffered from a massive inflow that was followed by a sudden stop. Recently, more advanced economies like Iceland and Greece also encountered sudden stops. Sudden stops refer to a collapse of capital inflows. The adjustment of relative prices followed by sudden stops often leads to significant losses on public and private balance sheets. These losses can spread throughout the financial system, triggering a broader financial crisis. A financial crisis is typically followed by a substantial growth slowdown or a contraction. Since sudden stops with currency crashes are more destructive than sudden stops without currency crashes (Hutchison and Noy, 2006), the topic of why some of the sudden stops are accompanied by a currency crash while others are not is important. As suggested by

Lane and Milesi-Ferretti (2012), we analyze whether the exchange rate regime in place matters here.

1.3 Currency crises

There are five "varieties" of financial crises: external default, domestic default, banking crises, currency crises, and inflation outbursts (Reinhart and Rogoff, 2008). A large number of studies concentrate on currency crises; some studies, such as Corsetti et al. (1999) and Corbett and Vines (1999), even use currency crisis and financial crisis interchangeably. The main currency crisis periods since 1980 are shown in Table 1.1.

Table 1.1 Timeline of main currency crises since 1980

Year	Countries:
1982	Mexico
1983	Israel
1992	Sweden, Finland
1992–93	Europe (Ireland, Italy, Spain, United Kingdom)
1994–95	Mexico
1997–98	Asia (Indonesia, Korea, Malaysia, Philippines, Singapore, Thailand)
1998	Russia
2000–2001	Turkey
2001	Argentina
2008-2009	Iceland

Source: Reinhart and Rogoff (2008) and Wikipedia.
http://en.wikipedia.org/wiki/Financial_crisis

The financial collapse in the US in 2008 quickly spread throughout the world, causing economic recessions in much of the EU, Turkey, and many other countries (Hausman and Johnston, 2012). Later on, some EU economies (Greece, Portugal, Ireland, Italy and Spain) faced a sovereign debt crisis. Currencies in several emerging economies depreciated sharply against the US dollar and the euro after the global financial crisis (Arduini et al., 2012). For instance, in September and October 2008 Iceland and South Africa experienced large depreciations (about 26% and 23% against US dollar within one month), while in November 2008 the Korean won lost 20% of its value *vis-à-vis* the US dollar. These large currency swings stimulated research on early warning indicators of currency crises. The recent financial crisis, which erupted in countries having different exchange rate regimes, has made it clear

that no exchange rate regime is a 'safe haven' in terms of crisis. As the first- and second-generation currency crises models from Krugman (1979) and Obstfeld (1994) show, currency crises may occur in a fixed exchange rate regime. Yet currency crises can also occur in countries with floating exchange rates or other regimes (Reinhart and Rogoff, 2004). There are several third-generation currency crisis models (such as McKinnon and Pill, 1999; Hausmann et al., 1999; Aghion et al., 2001) which link financial intermediaries and asset prices with the emergence of a currency crisis. These models explain the mechanism of currency crises irrespective of the exchange regime. Our aim is to gauge whether currency crises have different macro-economic causes under alternative exchange rate regimes.

1.4 Exchange rate regimes

After the East Asian financial crisis in 1997, it was widely believed that only extreme regimes, i.e. either hard pegs or floating regimes, would be sustainable since most crisis-hit economies had an intermediate foreign exchange rate regime before the crisis (Fischer, 2001). There is a lifely debate on the pros and cons of different regimes (Rose, 2011; Levy-Yeyati and Sturzenegger, 2003; Chang and Velasco, 2000; Eichengreen and Hausmann, 1999; Mishkin, 1999; Williamson, 1998). The pros of fixed regimes include the significant and positive effect of fixed exchange rates on trade (Klein and Shambaugh, 2006) and lower inflation due to imposing policy discipline (Ghosh et al, 1996). The cons include the lack of monetary autonomy (Shambaugh, 2004, and Obstfeld et al., 2005), the detrimental effects on the transmission of terms of trade shocks (Broda, 2004; Edwards and Levy-Yeyati, 2005), and the over-accumulation of foreign currency debt due to moral hazard (Radelet and Sachs 1999). The main advantage of flexible regimes is its role as a 'shock absorber' in a small open economy (Friedman, 1953; Mundell, 1961). The main disadvantage of floating regimes is the unpredictable volatility of the exchange rate, which reduces international trade and discourages investment (Hoffman, 2007). Although intermediate regimes can combine both the merits of fixed and floating regimes, the weakness of intermediate regimes is that they are less likely to revoke credibility (Frankel et al., 2000).

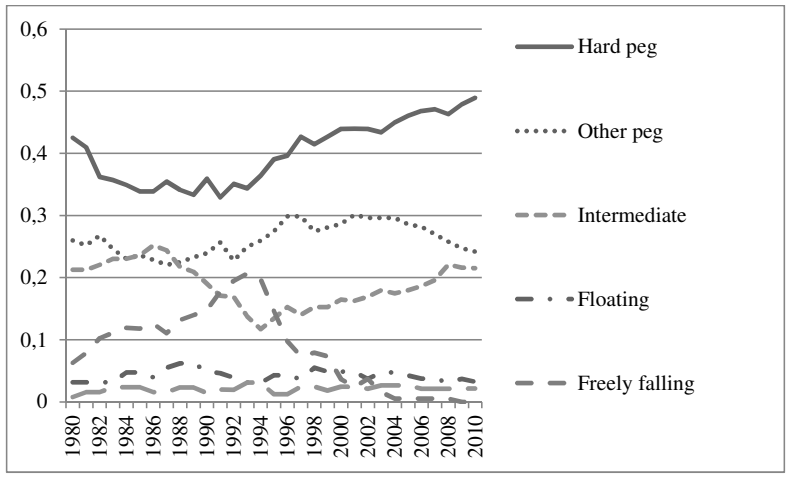
The IMF´s official classification of exchange rate regimes is widely used.[1] However, Calvo and Reinhart (2002) find that countries that say they allow their exchange rate to float mostly do not. This phenomenon stimulated authors to come up with *de facto* exchange rate regime classifications. Three well-known classifications are those developed by Levy-Yeyati and Sturzenegger (2003), Reinhart and Rogoff (2004), and Shambaugh (2004).[2] We use the classification of Reinhart and Rogoff (2004) since this classification has been updated to 2010.[3] Figure 1.2 shows the yearly share of different exchange rate regimes between 1980 and 2010. It appears that the shares of *de facto* hard pegs and intermediate regimes have increased during the most recent two decades. The proportion of hard pegs is 48.9% in 2010 compared to 32.9% in 1991. The proportion of intermediate regimes is 21.5% in 2010 compared to 11.7% in 1994. A number of countries have switched their exchange regimes. Some of them were forced to abandon their exchange rate regimes in the crisis period, such as Thailand in July 1997 and Argentina in January 2002. Some others adjusted their exchange rate regimes for other reasons (e.g., China in July 2005 and Canada in January 2002).

[1] IMF's Annual Report on Exchange Rate Arrangements and Exchange Restrictions.

[2] See Rose (2011) for a detailed discussion.

[3] See Ilzetzki et al. (2011).

Figure 1.2 The share of six different exchange rate regimes since 1980



Note: Hard peg = No separate legal tender + Pre announced peg or currency board arrangement + Pre announced horizontal band that is narrower than or equal to +/-2% + De facto peg; Other peg = Pre announced crawling peg + Pre announced crawling band that is narrower than or equal to +/-2% + De factor crawling peg + De facto crawling band that is narrower than or equal to +/-2%; Intermediate = Pre announced crawling band that is wider than or equal to +/-2% + De facto crawling band that is narrower than or equal to +/-5% + Moving band that is narrower than or equal to +/-2% (i.e., allows for both appreciation and depreciation over time) + Managed floating; Freely floating; Freely falling = Freely falling. Source: Ilzetzki et al. (2011).

The economies that were adversely affected by the 2008–2009 global financial crises have different exchange rate regimes: Greece, Ireland, Italy, Portugal and Spain have a hard peg; Chile and Russia belong to the category of other pegs; Brazil, Iceland, Korea and Romania have an intermediate regime, while Australia, South Africa, and Turkey have a floating exchange rate.

China implemented several economic measures to fight the global crisis, including changes in its exchange rate policy. The hard peg was reintroduced after the global financial crisis. So far, few papers have investigated the impact of the financial crisis on the forward exchange market. Arguably, this impact is related to (expectations about) the exchange rate policy. In addition, there is hardly any research examining the unbiased forward exchange rate hypothesis in transition economies. Under this hypothesis, given rational expectations and risk neutrality, the forward exchange rate is an unbiased predictor of the future spot exchange rate. The Chinese currency offers a very interesting case to examine the unbiasedness hypothesis, as there have been different exchange rate regimes in place after the exchange rate

policy reform in 2005. In July 2008, the People´s Bank of China (PBOC) returned to pegging the Renminbi to the US dollar. On June 19, 2010 the PBOC announced the return to a managed floating exchange rate regime under which the spot exchange rate can move intraday with at most 0.5 percent from the central parity.

1.5 Research questions

This dissertation focuses on international capital flows, currency crises and exchange rate regimes. We examine the following four research questions:

(1) Are Chinese hot money flows related to developments in the real estate and the stock markets, the interest rate differential vis-à-vis the US, the expected exchange rate appreciation, and the Chicago Board Options Exchange Market Volatility Index (VIX)? Does their effect depend on structural reforms and new regulations as well as the recent financial crisis? Are results affected by the choice of a particular measure for hot money?

(2) Which factors determine whether a sudden stop is followed by a currency crisis or not? Does the exchange rate regime play a role here?

(3) Are leading indicators of currency crises different in different exchange rate regimes? If so, which indicators are useful for different exchange rate regimes?

(4) What is the relationship between the Renminbi future spot return and the forward discount rate? Does the unbiased forward exchange rate hypothesis hold in China? What is the influence of the recent financial crisis on this relationship?

1.6 Outline of the thesis

In chapter 2, we investigate the determinants of hot money in China. We construct four measures of hot money for the January 2000 to December 2012 period. We use the Autoregressive distributed lag (ARDL) model which can be used regardless of whether variables are $I(0)$ or $I(1)$. Our main findings are the following: (i) The magnitude and the volatility of hot money flows are quite substantial over the last decade. (ii) Hot money flows appear to be consistently related to the expected appreciation of the Renminbi, independent of ways in which hot money is measured. However, the significance of the stock market index, the real estate climate index and the VIX depends on the way in which hot money is measured. (iii) The level of hot

money flows appears to be sensitive to the global financial crisis as we find that the volume of hot money significantly increased after the financial crisis. (iv) Reforms and regulations considered, including QFII and the exchange rate policy reforms, do not affect hot money flows. The regulation on foreign investment in the real estate market was effective. Our findings are consistent with previous studies concluding that the expected appreciation is a significant driver of hot money flows in China (Zhang and Shen, 2008; Shi and Xiao, 2011; Zhao et al., 2011).

In chapter 3, we distinguish different precursors for sudden stops with currency crashes and for sudden stops without currency crashes, with a special emphasis on the exchange rate regime in place. The literature suggests that not all countries respond to sudden stops in the same way (Calvo and Reinhart, 2000). Using both an event study and a probit model approach for 85 economies in the 1980-2012 periods, we find that economies with higher trade openness, deeper financial markets and with a surplus on their current account are more likely to maintain currency stability in the turmoil of sudden stops. In addition, economies with different exchange rate regimes behave differently. More specifically, the current account plays a role in the three types of exchange rate regime that we distinguish (i.e. hard pegs, other pegs and intermediate regimes). Budget deficits are significant in countries with hard pegs, while trade openness plays a role in both countries with a hard peg and in countries with other pegs. Financial development is a key factor in both other pegs and intermediate regimes.

In chapter 4, we examine the impact of the exchange rate regime in place on the significance of early warning indicators of currency crises. In attempting to provide an explanation for currency crises in alternative exchange rate regimes, we first review the currency crisis literature. We use both probit models and an approach based on Kaminsky et al. (1998). Following Frankel and Rose (1996), a currency crisis occurs if a currency depreciates by at least 25 percent annually while there is also at least a 10 percent-point increase in the rate of depreciation. Using data for 88 economies with different exchange rate regimes in the 1980-2010 periods, we find that external economic indicators, such as deviations of the real exchange rate from its trend and the growth of international reserves, have the strongest predictive power in fixed exchange rate regimes. In floating exchange rate regimes, macroeconomic policy indicators and credibility indicators, such as domestic credit growth and

inflation, are the best leading indicators of currency crises. Both external economic indicators and credibility indicators have predictive power in intermediate exchange rate regimes.

In chapter 5, we discuss the relationship between the Renminbi daily future spot return and the forward discount rate for the period after the Chinese authorities abandoned the US dollar peg (July 2005). We use break point tests from Zivot and Andrews (1992) and Bai and Perron (1998, 2003) as well as rolling cointegration tests to examine the time-varying relationship. We find that there were different regimes after this reform and that the financial crisis has affected the relationship between the future spot return and the forward discount rate in China. Four different sub-periods can be identified on the basis of our rolling cointegration analysis regarding the future spot return and the forward discount rate. First, there is cointegration before the financial crisis (July 2005–Spring 2008). Second, there is no cointegration in the early stages of the crisis (Spring 2008–Spring 2009). Arguably, the cointegration relationship is weak in the early stages of the crisis because at that time the trend of the Renminbi with respect to the dollar was very hard to predict. Third, there again is a cointegration relationship in the later stages of the global crisis (Spring 2009–Spring 2010). Apparently, when the financial crisis spread, the expectations from market participants became more uniform, namely that the Renminbi-dollar rate would stop appreciating for a while. It became easier for market participants to anticipate the exchange rate in the later stages of the crisis. Fourth, there is no cointegration after the Chinese government continued its policy of gradual appreciation (Summer 2010–Winter 2010) as the trend of the Renminbi with respect to the dollar again became hard to predict. Furthermore, we conclude that the unbiased forward rate hypothesis only holds when the spot exchange rate was almost invariant because the Chinese authorities had returned to pegging the Renminbi to the US dollar to overcome the turmoil caused by the global financial crisis. Our analysis shows a time-varying relationship between the Renminbi future spot return and the forward discount rate in the period after exchange rate regime reform.

Chapter 6 concludes with a discussion of the policy implications of our analyses. In addition, we discuss some limitations of our work and provide suggestions for future research.

Chapter 2

The Dynamics of Hot Money in China

2.1 Introduction

Emerging economies have been confronted with financial instability for decades. China, currently the biggest emerging market, is no exception. The recent increase in the level and volatility of hot money flows is widely considered to have generated financial instability in China (Martin and Morrison, 2008; Ljungwall and Wang, 2008). Hot money can be defined as capital flows that are not related to the trade surplus or foreign direct investment.[4] Although China has taken some measures to restrict hot money flows, several authors argue that these have not been very effective (Martin and Morrison, 2008; Tsuyuguchi, 2009; Guo and Huang, 2010b).

Both the expansion and the volatility of hot money flows have raised concerns about their impact on financial stability. Given the sensitivity of hot money flows, even a small shock to the economy can lead to large fluctuations in hot money flows, which in turn may exacerbate the shock and further destabilize the financial system and the domestic economy (Sarno and Taylor, 2003; Bouvatier, 2010). Furthermore, hot money flows may reduce the effectiveness of monetary and exchange rate policies (Glick and Hutchison, 2009; Guo and Huang, 2010a). It has also been argued that hot money inflows have fueled inflation, driven up stock prices and accelerated a worrisome bubble in the real estate market in China (Guo and Huang, 2010a). Therefore, it is of great importance to study the drivers of hot money flows.

Several studies have already analyzed the determinants of hot money flows.[5] However, a major limitation of these studies is that the techniques employed only allow testing long-run relationships under the restrictive assumption that all the variables in the system are $I(0)$ or all variables are $I(1)$ (stationary or first difference

[4] See Tung and Baker (2004), Zhang and Fung (2006), Martin and Morrison (2008), and Guo and Huang (2010a).

[5] Relevant references include: Shi and Xiao (2011); Zhao et al. (2011); Cheung and Xian (2010b); Ljungwall and Wang (2008); Sicular (1998); and Gunter (1996, 2004).

stationary). But, as will be shown in Section 2.5, this is not the case in China probably due to structural changes, such as the exchange rate policy reform, the launch of the qualified foreign institutional investors (QFII) system and regulations which restrict foreign investment in the real estate market, and major shocks, such as the recent financial crisis. The only study which takes structural changes into account is Cheung and Qian (2010b), who use several China-specific institutional factors—including a political risk index, a dummy variable allowing the effect of the US–China Strategic Economic Dialogue, a dummy variable for exchange rate policy reform, and a dummy variable tracking the evolution of China's capital control policy. They find that the relevance of the selected institutional factors depends on both data frequency and regression specification.

A second limitation of previous studies is that they generally do not examine to what extent their findings depend on a specific measure of hot money. As will be shown in Section 2.2, several methods have been used to measure hot money, which may lead to different results. We therefore employ several measures of hot money.

In addition, we intend to test for the institutional factors related to hot money flows in China. Are hot money flows related to developments in the real estate and the stock markets, the interest rate differential vis-à-vis the US, the expected exchange rate appreciation, and market volatility? And is their effect depending on structural reforms, new regulations and the financial crisis? We use Autoregressive Distributed Lag (ARDL) models introduced by Pesaran et al. (1999), which can be used to examine long-run relationships regardless of whether the underlying variables are $I(0)$, $I(1)$, or fractionally integrated. Furthermore, ARDL models are applicable even when the explanatory variables are endogenous. We will use four alternative measures of hot money.

This chapter contributes to the literature as follows. First, we investigate the determinants of hot money flows in China. Our sample includes the recent financial crisis, so that we can analyze its impact. Milesi-Ferretti and Tille (2011) report an unprecedented collapse in international capital flows during the recent crisis suggesting that hot money may have become more volatile during the crisis period. Second, we test for the impact of reforms and new regulations, such as the introduction of the qualified foreign institutional investors (QFII) in July 2003, the exchange rate policy reform in July 2005, and new regulations on foreign investment

in real estate in July 2006. The impact of driving factors of hot money flows, for example exchange rate expectations, can be time varying because of these reforms and regulations although their direction is uncertain. For instance, Corbo and Hernandez (1996) argue that a more flexible exchange rate system may lead to excessive volatility in hot money, whereas Ghosh et al. (2012) argue that a fixed exchange rate may encourage greater cross-border borrowing and lending. Finally, we construct four measures of hot money. The first one is found by subtracting the trade surplus and net foreign direct investment (FDI) from the change in official foreign reserves. The second measure uses adjusted foreign reserves instead of official foreign reserves. The third one adds a rough estimation of hot money flows in trade invoicing to the second measure. The final proxy uses data of the current account instead of net exports of goods. In constructing these measures we employ the new balance of payments (BOP) statistics issued on April 1, 2011.[6]

Our main findings are as follows. First, over the last decade, hot money flows in China have been large and increasing. In line with the findings of previous studies, our results suggest that the expected appreciation of the RMB is significantly related to hot money flows in China. The interest rate differential *vis-à-vis* the US turns out to be insignificant. The significance of the real estate and stock markets, and of market volatility differs across measures of hot money. Second, the recent global financial crisis significantly increased the levels of hot money flows in China but only when we use the second and the third measures of hot money. Third, most of the regulations and reforms we consider do not affect the drivers of hot money. An exception is the regulation of foreign investment in the real estate market.

The remainder of the chapters structured as follows. Section 2.2 reviews the definitions of hot money and provides an overview of hot money in China since 2000. Section 2.3 discusses the factors which could be associated with hot money flows. Section 2.4 explains the estimation techniques employed, while Section 2.5 reports the empirical results. Section 2.6 considers the influences from reforms, new regulations and the financial crisis. Finally, Section 2.7 concludes.

[6] The State Administration of Foreign Exchange (SAFE) issued BOP statistics using a new format on April 1, 2011, in which retained profits on foreign direct investment (FDI) are taken into account.

2.2 Background

In this section, we first review the definition of hot money, and then we analyze hot money flows to China since 2000.

Corbo and Hernandez (1996) define hot money as short-term, highly volatile capital inflows usually attracted by market imperfections or policy mistakes that create a large gap between domestic and foreign interest rates, adjusted for exchange rate expectations. Kim and Singal (2000) characterize hot money as international capital flows that are not only highly sensitive to differences in interest rates, but also to expectations of future economic growth, and expected returns on holding securities. In the view of Glick and Hutchison (2000), hot money is particularly footloose, seeking the highest global return, and is quite speculative in nature. Hence, funds are likely to flow out of a country just as quickly as they flow in, often without any fundamental cause. Martin and Morrison (2008) use the term 'hot money' in financial markets to refer to the flow of capital from one country to another in order to earn a short-term profit on interest rate differentials and/or anticipated exchange rate shifts. Glick and Hutchison (2009) interpret non-FDI capital inflows that could potentially switch direction within a short horizon as hot money. Sula (2010) considers portfolio flows and private loans as hot money flows. In sum, the most distinguishing feature of hot money is that it can be reversed quickly.

Scholars use either a direct or an indirect way to measure hot money (see Table 2.1 for a summary). The direct method uses data for specific variables that constitute hot money. The indirect method captures hot money as a residual of other variables.[7]

[7] See Kant (1996) for a detailed description of various hot money measures and their limitations.

Table 2.1 Hot money measurement

Direct way		Indirect way	
Study:	**Method:**	**Study:**	**Method:**
Prasad and Wei (2007) Cheung and Qian (2010a)	Errors and omissions portfolio flows	Zhang and Fung (2006) Martin and Morrison (2008) Tung and Baker (2004) Guo and Huang (2010a & 2010b)	Subtract trade surplus (or deficit) and net flow of foreign direct investment (FDI) from the change in foreign reserves
Loungani and Mauro (2001)	Net errors and omissions (1) Net flows of non-FDI, non-portfolio investment assets and liabilities held by entities other than the monetary authorities, general government, and banks (2)		
Loungani and Mauro (2001)	(1) and (2) plus net flows of non-FDI, non-portfolio investment assets and liabilities held by banks		

A limitation of the direct method is that the errors and omissions in the BOP statistics includes not only unrecorded capital flows but also measurement and rounding errors, unreported imports, and registration delays. These items not necessarily need to be hot money. A drawback of the indirect method is that it assumes that there is no hot money in net exports and FDI. This is also not the case. In sum, neither the direct method nor the indirect method is able to record hot money flows precisely. We therefore use four alternative measures of hot money based on the indirect method as shown in Table 2.1. Our motivation for using the indirect method is that it is applicable to monthly data, whereas the direct ways can only be used on quarterly or yearly bases. Our first proxy is found by subtracting the trade surplus and FDI from the change in official foreign reserves. We construct a second measure by using adjusted foreign reserves instead of official reserves, following Zhang and Xu (2008). The reason for using adjusted foreign reserves is that foreign reserves may change even when there are no capital flows. First, foreign reserves in China mainly consist of US dollars, Euros and Japanese Yen. If the Euro appreciates vis-à-vis the US dollar, the stock of foreign reserves of China increases even though there is no capital flow. Second, when the China Investment Corporation (CIC) was founded in

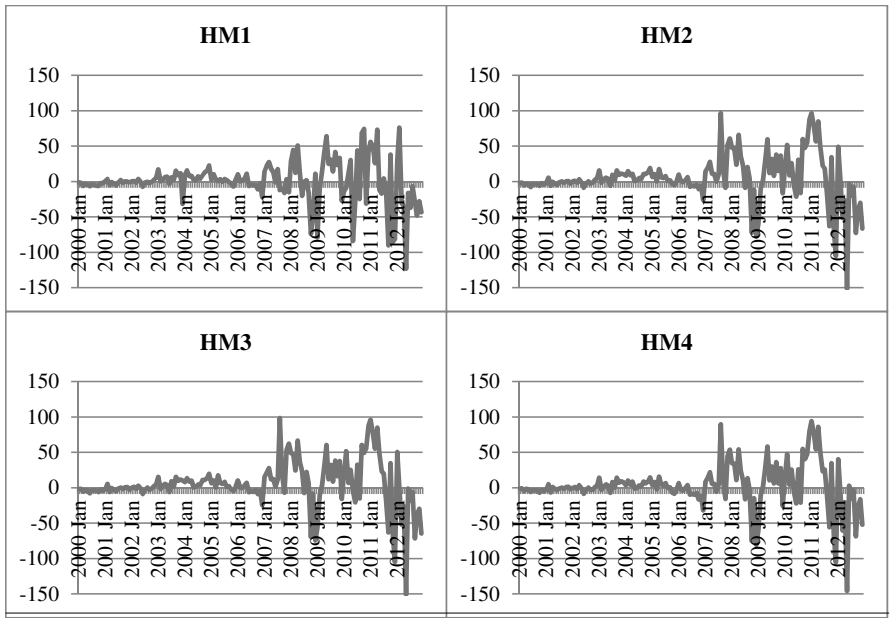
September 2007, some official foreign reserves were shifted to CIC.[8] These funds should be added to foreign reserves in the corresponding period. Third, state-owned banks received capital injections coming from foreign reserves. These injections should also be added to foreign reserves. Fourth, deposit reserve requirements in foreign currency were imposed on major banks. The amounts of frozen foreign currency should be added to the stock of foreign reserves accordingly. Finally, foreign-exchange swap transactions between the People's Bank of China (PBOC) and major commercial banks in China took place. Unfortunately, these transactions are hard to track since the PBOC does not announce them. We therefore only adjust foreign reserves for the first four factors outlined above.[9]

Our third proxy adds to the second measure a rough estimation of hot money in trade invoicing.[10] The trade surplus in China suddenly increased following the exchange rate regime reform in July 2005. We assume that the structure of imports and exports is stable since 2000. The ratio of trade surplus to total trade should fluctuate around a baseline, which we calculate as the ratio of trade surplus to total trade between January 2000 and June 2005. The difference from this baseline is considered as hot money in trade invoicing (Zhang and Xu, 2008).[11] To construct the final measure we use the current account instead of net exports of goods.

We calculate hot money for the period from January 2000 to December 2012. The quarterly data on FDI comes from BOP. We construct monthly FDI and current account data from quarterly FDI and current account following Cheung and Qian (2010b).[12] The monthly data for exports of goods, imports of goods and foreign reserves come from the IMF's International Financial Statistics (IFS).

[8] CIC is a sovereign-wealth fund aiming to make profits using foreign exchange assets held by the Chinese government.
[9] See Appendix 2.A for a detailed description of adjusted foreign reserves.
[10] We also considered tracking hot money in FDI, but it is hard to get data on a monthly basis.
[11] See Appendix 2.B for more details.
[12] See Chow and Lin (1971) for more details. Net FDI is derived using data on inward FDI from the Ministry of Commerce of the People's Republic of China.

Figure 2.1 Hot money flows in China



Note: Unit: Billion US Dollars. HM1: Change in foreign exchange reserves - Net exports of goods - Net foreign direct investments. HM2: Change in adjusted foreign exchange reserves - Net exports of goods - Net foreign direct investments. HM3: Change in adjusted foreign exchange reserves - Net exports of goods - Net foreign direct investments + Hot money in trade invoicing. HM4: Change in adjusted foreign exchange reserves - Net current account - Net foreign direct investments + Hot money in trade invoicing.

Figure 2.1 shows that the four alternative measures of hot money have a very similar trend. Hot money generally flew out of China before 2002, while thereafter it flew into China until the start of the global financial crisis in 2008. Between 2002 and 2008, net inflows of hot money in China amounted to at least 207 billion US dollars according to our first measure (HM1). The amount is 626 billion US dollars according to the third measure (HM3). On July 21, 2005, China announced the abolition of its fixed nominal exchange rate to the US dollar. Since then, hot money flows became more volatile. McKinnon et al. (2010) argue that between July 2005 and July 2008, a "one-way bet on appreciation of RMB" stimulated hot money inflows to China. In July 2008, when the global financial crisis provoked an unwinding of the dollar carry trade with a sharp appreciation of the dollar against most other currencies, the PBOC returned to pegging the RMB to the US dollar (see Zhao et al., 2013 for details). The Chinese authorities motivated their decision as part of the efforts to overcome the

temporary interruption of the reform process that was caused by the global financial crisis. On June 19, 2010 the PBOC announced the return to a managed floating exchange rate regime under which the spot exchange rate can move intraday by at most 0.5 percent from the central parity. The RMB started appreciating again (Eichengreen and Rose, 2010) and hot money inflows into China grew dramatically as illustrated in Figure 2.1.

There are three periods with net hot money outflows in China as shown in Figure 2.1. The first period started in October 2008, when the global financial crisis intensified due to the fall of Lehman Brothers. The hot money flows out of China amounted to about 200 billion US dollars from October 2008 to February 2009 according to our four measures. Milesi-Ferretti and Tille (2011) indicate that this period was characterized by a reversal of capital flows, with investors across the globe liquidating holdings abroad. In addition, the State Council in China announced a new regulation on foreign exchange management on August 2008. This regulation required that all cross-border flows of foreign exchange recorded as entries in the trade account must be truly the results of trade transactions and those recorded as entries of investment income must be truly investment income (Yu, 2009). Authorities had to approve the use of RMB funds originating from selling foreign exchange to the State Administration of Foreign Exchange (SAFE).[13] The second period of capital outflows started from the intensification of the European sovereign debt crisis, which is dated as March 2010 in Fratzscher (2012). The third period with outflows started in September 2011 and intensified in May 2012. The annual outflow of hot money was about 300-400 billion US dollars in 2012 according to our measures. This was the largest outflow in one year.

2.3 Factors associated with hot money

There is a small but rapidly growing literature on the factors associated with hot money flows. Kim and Singal (2000) argue that hot money flows are highly sensitive to differences in interest rates, expectations of future economic growth, and expected

[13] Foreign currency is not allowed to circulate in China. Foreign currency has to be sold to banks to get RMB and the purpose of this transaction has to be approved by SAFE.

returns from holding securities. According to Bouvatier (2010), the US interest rate and exchange rate revaluation are important factors in explaining hot money inflows. McCauley (2010) poses that prospects for strong performance of Asian economies and currency appreciation (or at least relative stability of Asian currencies) have led to an acceleration of equity inflows, debt inflows, bond market inflows, bank flows and carry trades in Asia.

Studies on hot money in China emphasize different factors. Martin and Morrison (2008) point to two key factors: the interest rate differential vis-à-vis the United States and expectations of an appreciation of the RMB. Zhang and Fung (2006) and Guo and Huang (2010a) argue that hot money mainly flows to the stock and real estate markets in China. Zhang and Shen (2008) show that the appreciation of the RMB and rising stock prices are determinants of hot money flows in China. Likewise, Yu (2010) poses that market participants were betting on an increase in the RMB exchange rate and rising property and equity prices. Similarly, Shi and Xiao (2011) find that the main incentives for hot money flows in China are revenues from investments in stock and real estate markets. The expected appreciation of the RMB also has driven hot money in China according to this study, but the interest differential *vis-à-vis* the US seems to have had no effect. Zhao et al. (2011) find that rising house prices were the most significant factor related to hot money flows in China, followed by the exchange rate and interest rate differentials; stock prices had the weakest impact. In sum, although previous studies focus on similar drivers of hot money flows, they do not come to the same conclusion as to the factors associated with the expansion of hot money flows in China. A possible reason for these diverse findings is that the studies use different sample periods and different methods for measuring hot money. In addition, the methods used, either OLS or VAR models, require that all variables are $I(0)$ or all are $I(1)$, and this may not be true in China which is in a process of financial reform.

We use two groups of explanatory factors based on previous studies: global and domestic macroeconomic variables. We use interest rate differentials *vis-à-vis* the US

as well as the Chicago Board Options Exchange Market Volatility Index[14] (VIX) to capture the global factor. If Chinese interest rates are higher than those in the US there arguably will be more hot money inflows to China. A higher VIX is expected to cause more hot money inflows to China. We consider three domestic macroeconomic variables, namely the stock market index, the real estate climate index and expectations for the future RMB exchange rate. The stock market index and the real estate climate index[15] are included to capture flows aiming at acquiring profits from rising asset prices. Expectations for the future RMB exchange rate are included to take up exchange rate speculation. There will be hot money inflows when the stock and real estate index rise, and when the RMB is expected to appreciate. We use the monthly Shanghai Stock Exchange Composite Index and VIX (both from DataStream). The interest rate differential between China and the United States equals the one-month interbank offering rate difference between China and the United States; both interest rates come from Reuters. The real estate climate index comes from the National Bureau of Statistics of China. The expected depreciation of the RMB (EE) can be derived using the following equation: $EE = \frac{E^e - E_0}{E_0}$. Non-deliverable forward (NDF) is a proxy for the expected exchange rate E^e, which originates from Bloomberg. The RMB offshore non-deliverable forwards are not officially subject to China's jurisdiction and, thus, could be viewed as a market indicator of expected currency movements (Cheung and Qian, 2010b). The spot exchange rate (E_0) is also from DataStream.

2.4 Methodology

Pesaran et al. (1999) propose the Autoregressive Distributed Lag (ARDL) model. This method can be used regardless of whether the variables are *I*(0) or *I*(1)

[14] VIX is a measure of expected volatility of S&P 500 index options. It represents the market's expectation of stock market volatility over the next 30 days. It is often referred to as the fear index or the fear gauge. A rise in the VIX caused capital to flow into emerging markets. However, this effect reversed during the crisis, when the sharp increase in global risk induced capital outflows (Fratzscher, 2012) due to flight-to-safety. Other papers including VIX as a determinant of capital flow are Forbes and Warnock (2012) and Bruno and Shin (2012).

[15] The real estate climate index shows the same trend as the real estate price index. The latter is only available on a monthly basis from June 2005 to December 2010.

(stationary or first difference stationary). Another merit of ARDL models is that they are applicable even when the explanatory variables are endogenous (Fedderke and Liu, 2002). The ARDL procedure consists of two steps. First, it tests the existence of a long-run relationship between the variables in the system using the so-called bound test, which is an F-test. The model is shown as:

$$\Delta \mathrm{HM}_t = \propto_0 + \propto_1 t + \sum_{i=1}^{p} \propto_2 \Delta HM_{t-i} + \sum_{i=1}^{p} \propto_3 \Delta EE_{t-i} + \sum_{i=1}^{p} \propto_4 \Delta ID_{t-i} + \sum_{i=1}^{p} \propto_5 \Delta SI_{t-i} + \sum_{i=1}^{p} \propto_6 \Delta RC_{t-i} + \sum_{i=1}^{p} \propto_7 \Delta VIX_{t-i} + \propto_8 HM_{t-i} + \propto_9 EE_{t-i} + \propto_{10} ID_{t-i} + \propto_{11} SI_{t-i} + \propto_{12} RC_{t-i} + \propto_{13} VIX_{t-i} + \varepsilon_t \quad (2.1)$$

where p is the lag order, t is time trend, ε is error term, *HM* is hot money, *EE* is expected depreciation, *ID* is interest rate differential, *SI* is the stock market index, *RC* is the real estate climate index and *VIX* is Chicago Board Options Exchange Market Volatility Index. In our model, as shown in equation (2.1), the null hypothesis of no cointegration as defined by H_0: $\alpha_8 = \alpha_9 = \alpha_{10} = \alpha_{11} = \alpha_{12} = \alpha_{13} = 0$ is tested against the alternative H_1: $\alpha_8 \neq 0$, $\alpha_9 \neq 0$, $\alpha_{10} \neq 0$, $\alpha_{11} \neq 0$, $\alpha_{12} \neq 0$, $\alpha_{13} \neq 0$ using F-statistics. The critical values of the F-statistics for this test are available in Pesaran et al. (2001). They provide two sets of critical values in which one set is computed under the assumption that all variables in the ARDL model are *I*(1), and the other under the assumption that they are all *I*(0). For each application, the two sets provide the bands covering all the possible classifications of the variables into *I*(0) or *I*(1), or even fractionally integrated ones. If the computed F-statistic is higher than the upper bound of the critical value, the null hypothesis of no cointegration is rejected. If it is below the lower bound, the null hypothesis cannot be rejected. If it lies within the lower and upper bounds, the result is inconclusive.

If the results of the F-test in the first step suggest cointegration, we move to the second step of the ARDL approach. The following long term model (2.2) is estimated:

$$\mathrm{HM}_t = \beta_1 + \gamma_{1i} \sum_{i=1}^{p} HM_{t-i} + \delta_{1i} \sum_{i=0}^{p} EE_{t-i} + \varepsilon_{1i} \sum_{i=0}^{p} ID_{t-i} + \zeta_{1i} \sum_{i=0}^{p} SI_{t-i} + \eta_{1i} \sum_{i=0}^{p} RC_{t-i} + \theta_{1i} \sum_{i=0}^{p} VIX_{t-i} + \mu_t \quad (2.2)$$

In this step, the lag order of the variables is chosen according to the Schwarz Bayesian Criterion (SBC).

2.5 Results

In this section, we first perform ADF unit root tests for each variable to see whether all variables are either $I(0)$ or $I(1)$. Secondly, we perform bound tests using model (2.1) to see whether there are long-term cointegrating relationships among variables. Thirdly, we estimate the ARDL model using the SBC criterion to determine the optimal lag order of each variable in the system. The long-run parameters of the ARDL model and error correction representation of the selected ARDL model are followed by.

First we perform ADF unit root tests for each variable.[16] The tests are conducted against three alternatives: stationary fluctuations around zero, stationary fluctuations around a constant term and stationary fluctuations around a constant term and a time trend. Table 2.2 reports the results and shows that all variables are either $I(0)$ or $I(1)$.

[16] We also performed alternative unit root tests developed by Elliott et al. (1996) and Phillips and Perron (1998). These tests give the same outcomes as the ADF tests (results available on request).

Table 2.2 Augmented Dickey-Fuller tests

		Level		First difference	
		Lag length	t-statistic	Lag length	t-statistic
Hot Money 1	(0,0)	0	-9.4792***		
	(c,0)	0	-9.4481***		
	(c,t)	0	-9.4736***		
Hot Money 2	(0,0)	2	-3.1990***		
	(c,0)	2	-3.2089**		
	(c,t)	2	-3.1616*		
Hot Money 3	(0,0)	2	-3.1412***		
	(c,0)	2	-3.1597***		
	(c,t)	2	-3.1075***		
Hot Money 4	(0,0)	2	-3.4329***		
	(c,0)	2	-3.4285**		
	(c,t)	2	-3.3963*		
Expected depreciation	(0,0)	1	-2.7222***		
	(c,0)	1	-2.7411*		
	(c,t)	1	-2.6909	0	-17.3559***
Interest rate differential	(0,0)	0	-0.9746	0	-11.5605***
	(c,0)	0	-1.2443	0	-11.6027***
	(c,t)	0	-1.6770	0	-11.5644***
Stock market index	(0,0)	2	-0.7173	1	-6.5283***
	(c,0)	6	-2.4850	1	-6.5078***
	(c,t)	6	-2.9273	1	-6.4819***
Real estate climate index	(0,0)	1	-0.2508	0	-5.3595***
	(c,0)	1	-2.6296*		
	(c,t)	1	-3.2917*		
VIX	(0,0)	2	-1.1500	1	-10.2140***
	(c,0)	1	-3.8523***		
	(c,t)	1	-3.8395**		

Notes: This table shows the outcomes of the ADF test. The lag length is based on the SBC criterion. (0, 0) refers to the model without constant and without time trend. (c, 0) refers to the model with constant but without time trend. (0, t) refers to the model without constant but with time trend. (c, t) refers to the model with constant and time trend. *** Rejection of the null hypothesis at the 1% level; ** Rejection of the null hypothesis at the 5% level; * Rejection of the null hypothesis at the 10% level.

In the second step, we perform bound tests using model (2.1) to see whether there are long-term cointegrating relationships among the variables. The results for the F-tests are given in Table 2.3, showing whether the values of the F-statistics are above the critical values (CV) provided by Pesaran et al. (2001) using different lag orders *p*. These tests generally support the existence of a long-run relationship between hot

money flows and the five factors we investigated, irrespective of their order of integration. Only a few cases where exclude the constant items reject the existence of a long-run relationship between hot money flows and the factors.

Table 2.3 Results of bound tests (F-statistics)

Lag order (*p*)	1	2	3	4	5	6
HM1 (0,0)	8.7476***	4.1413***	5.5856***	4.3692***	2.7725**	2.6759**
HM1 (c,0)	8.8467***	4.2709***	5.7517***	5.6122***	3.4465***	3.3350***
HM1 (0,t)	8.6349***	4.1273***	5.4575***	4.1094***	2.5273**	2.5735**
HM1 (c,t)	8.7378***	4.2005***	5.7284***	5.7523***	3.6007***	3.8981***
HM2 (0,0)	5.1952***	2.4603**	2.9325**	1.9243*	1.5204	1.5954
HM2 (c,0)	5.7248***	2.6723**	3.2723***	3.0734***	2.4589**	2.4620**
HM2 (0,t)	5.2779***	2.4498**	2.8535**	1.7371	1.3780	1.5237
HM2 (c,t)	5.6103***	2.6059**	3.4271***	3.3333***	2.8386**	3.1713***
HM3 (0,0)	5.2732***	2.4313**	2.8829**	1.8981*	1.4970	1.5723
HM3 (c,0)	5.7919***	2.6155**	3.1948***	3.0060***	2.4139**	2.4232**
HM3 (0,t)	5.3319***	2.4094**	2.8115**	1.7142	1.3590	1.5052
HM3 (c,t)	5.6809***	2.5550**	3.3780***	3.2999***	2.8213**	3.1652***
HM4 (0,0)	5.1579***	2.3278**	2.7939**	1.9192*	1.6007	1.7289
HM4 (c,0)	5.4637***	2.4112**	2.9307**	2.7797**	2.3555**	2.5021**
HM4 (0,t)	5.2502***	2.3199**	2.7360**	1.7540	1.4766	1.6754
HM4 (c,t)	5.3735***	2.3562**	3.0331***	3.0243***	2.7380**	3.1657***

Notes: This table shows F tests using model (2.1) using different lag orders shown in the first row. The asterisk denotes test statistics above upper bound critical value. *, **, and *** means significant at the 10%, 5%, and 1% level, respectively. HM (0, 0) gives F statistic for models without constant and without time trend t. HM (c, 0) gives F statistic for models with constant without time trend t. HM (0, t) gives F statistic for models without constant with time trend t. HM (c, t) gives F statistic for models with constant and time trend t.

In the third step, we estimate the ARDL model using the SBC criterion to determine the optimal lag order of each variable in the system. The maximum lag is set at 4 so that the sample period for analysis becomes 2000M5 to 2012M12. Using Microfit 4.1, the optimal models for our four measurements of hot money are: ARDL (1,0,0,0,0,4), ARDL (1,0,0,0,1,0), ARDL (3,0,0,0,1,0) and ARDL (1,0,0,0,1,0) for our different measures of hot money. The results of these ARDL models are summarized in Table 2.4.

Table 2.4 Autoregressive Distributed Lag Model: estimation results

(1)	HM1 (2)	HM2 (3)	HM3 (4)	HM4 (5)
Hot money (-1)	0.1639**	0.2222***	0.2134***	0.1231
	(0.0750)	(0.0796)	(0.0798)	(0.0804)
Hot money (-2)				0.1275
				(0.0805)
Hot money (-3)				0.1907**
				(0.0808)
Expected depreciation	-0.2085***	-0.2359***	-0.2325***	-0.2023***
	(0.0714)	(0.0801)	(0.0800)	(0.0766)
Interest differential	-0.0462	0.2002	0.1833	0.2120
	(0.1279)	(0.1329)	(0.1327)	(0.1284)
Stock market index	0.0252	0.5699*	0.5877*	0.4696
	(0.2855)	(0.3277)	(0.3278)	(0.3134)
Real estate climate index	16.5885	109.7165***	108.3947**	98.7407**
	(10.3324)	(41.3042)	(41.2611)	(40.0626)
Real estate climate index (-1)		-90.5439**	-88.6685**	-96.3275**
		(39.2860)	(39.2543)	(37.6866)
VIX	-1.4998***	-0.0882	-0.0744	-0.1768
	(0.4856)	(0.2914)	(0.2911)	(0.2795)
VIX(-1)	0.4038			
	(0.4856)			
VIX(-2)	2.2370***			
	(0.7369)			
VIX(-3)	-3.1427***			
	(0.7422)			
VIX(-4)	2.5803***			
	(0.4847)			
Constant	-18.5671*	-20.4321*	-21.0929*	-2.6635
	(11.0072)	(11.4803)	(11.4808)	(11.6339)
Trend	0.0012	-0.0026	-0.0016	-0.0081
	(0.0090)	(0.0096)	(0.0096)	(0.0092)
R-Squared	0.3850	0.3861	0.3806	0.3850
R-Bar-Squared	0.3506	0.3378	0.3459	0.3414
F-stat.	11.1896***	8.0032***	10.9816***	8.8276***
Serial Correlation	3.1054***	2.2766**	3.2795***	2.8878***
Functional Form	1.1649	0.8891	1.3741	0.7498
White Heteroscedasticity	4.9095**	0.2933	4.5466**	3.2487*

Notes: The dependent variable is hot money flows. Hot money (-1), Hot money (-2) and Hot money (-3) are the first, second and third lag of hot money, respectively. The ARDL (1,0,0,0,0,4), ARDL (1,0,0,0,1,0), ARDL (3,0,0,0,1,0) and ARDL (1,0,0,0,1,0) are selected based on Schwarz Bayesian Criterion. The standard errors are shown in parentheses. *** Rejection of the null hypothesis at the 1% level; ** Rejection of the null hypothesis at the 5% level; * Rejection of the null hypothesis at the 10% level.

Table 2.4 indicates that the overall goodness of fit of the estimated equations is reasonably good (R^2=0.39 or 0.38). The diagnostic test results show that our models pass the tests for functional form. However, the results indicate that there exists serial correlation and heteroscedasticity when we use our hot money measures 1, 2 and 4. But this does not affect the parameter estimates (Laurenceson and Chai, 2003; Shrestha and Chowdhury, 2007). Estimates of the long-run coefficients based on the ARDL model are reported in Table 2.5, while the Error Correction Model is shown in Table 2.6.

Table 2.5 Estimated long-run parameters of the ARDL model

(1)	HM1 (2)	HM2 (3)	HM3 (4)	HM4 (5)
Expected depreciation	-0.2494***	-0.3033***	-0.2956***	-0.3620**
	(0.0877)	(0.1050)	(0.1037)	(0.1509)
Interest differential	-0.0553	0.2574	0.2330	0.3795
	(0.1528)	(0.1709)	(0.1689)	(0.2291)
Stock market index	0.0301	0.7326*	0.7471*	0.8405
	(0.3413)	(0.4135)	(0.4087)	(0.5578)
Real estate climate index	19.8400	24.6484*	25.0766*	4.3187
	(12.1381)	(13.4968)	(13.3345)	(19.4385)
VIX	0.6921*	-0.1133	-0.0946	-0.3164
	(0.3804)	(0.3739)	(0.3695)	(0.5013)
Constant	-22.2064*	-26.2675*	-26.8140*	-4.7668
	(12.9317)	(14.1911)	(14.0208)	(20.4192)
Trend	0.0014	-0.0034	-0.0020	-0.0144
	(0.0108)	(0.0123)	(0.0122)	(0.0169)

Notes: The dependent variable is hot money flows. This table shows the long-run parameters based on the estimates shown in Table 2.4. The standard errors are shown in parentheses. *, **, and *** means significant at the 10%, 5%, and 1% level, respectively.

The coefficients of the expected exchange rate and VIX are significant when we use our first measure of hot money as the dependent variable (column 2 in Table 2.5). A higher volatility of the S&P 500 index options and an exchange rate appreciation lead to higher capital inflows. The coefficients of the expected exchange rate change, the stock market index, and the real estate climate index are significant with the expected sign when we use the second and third measures of hot money as the dependent variable (columns 3 and 4 in Table 2.5). An expected appreciation of the

RMB exchange rate, a rising stock market and a rising real estate index induce hot money inflows. The expected exchange rate is the only significant variable when we use our fourth measure of hot money. Our finding of a significant impact of the expected appreciation is in line with the findings of previous studies (Zhang and Shen, 2008; Shi and Xiao, 2011; Zhao et al., 2011). The coefficient of the interest rate differential is always insignificant. Also this finding is in line with those of several earlier studies. Although theoretically the interest rate differential is a trigger of hot money, few empirical studies find it to be significant in China (Cheung and Qian, 2010b; Shi and Xiao, 2011). This is probably reflecting that interest rates in China are regulated by the central bank and are not determined by market forces (Goldstein and Lardy, 2006). In addition, Chinese money markets are not accessible to everyone (Cheung and Qian, 2010b). We find that the significance of the stock market index, the real estate climate index, and the VIX depends on the choice for a particular measure of hot money.

Table 2.6 Error correction representation of the selected ARDL model

(1)	HM1 (2)	HM2 (3)	HM3 (4)	HM4 (5)
D(Hot money (-1))				-0.3182***
				(0.1033)
D(Hot money (-2))				-0.1907**
				(0.0808)
D(Expected depreciation)	-0.2085***	-0.2359***	-0.2325***	-0.2023***
	(0.0714)	(0.0801)	(0.0800)	(0.0766)
D(Interest differential)	-0.0462	0.2002	0.1833	0.2120
	(0.1279)	(0.1329)	(0.1327)	(0.1284)
D(Stock market index)	0.0252	0.5699*	0.5877*	0.4696
	(0.2855)	(0.3277)	(0.3278)	(0.3134)
D(Real estate climate index)	16.5885	109.7165***	108.3947**	98.7407**
	(10.3324)	(41.3042)	(41.2611)	(40.0626)
D(VIX)	-1.4998***	-0.0882	-0.0744	-0.1768
	(0.4856)	(0.2914)	(0.2911)	(0.2795)
D(VIX(-1))	-1.6746***			
	(0.5282)			
D(VIX(-2))	0.5624			
	(0.4957)			
D(VIX(-3))	-2.5803***			
	(0.4847)			
D(Constant)	-18.5671*	-20.4321*	-21.0929*	-2.6635
	(11.0072)	(11.4803)	(11.4808)	(11.6339)
D(Trend)	0.0012	-0.0026	-0.0016	-0.0081
	(0.0090)	(0.0096)	(0.0096)	(0.0092)
ECM (-1)	-0.8361***	-0.7779***	-0.7866***	-0.5588***
	(0.0750)	(0.0796)	(0.0798)	(0.1136)
R-Squared	0.4179	0.5857	0.4211	0.4733
R-Bar-Squared	0.3853	0.5532	0.3888	0.4359
F-stat.	14.6643***	19.7935***	14.8621***	14.0779***

Notes: The dependent variable is the first difference of hot money flows. ECM denotes error correction term obtained from the long-run relationship. The standard errors are shown in parentheses. *, **, and *** means significant at the 10%, 5%, and 1% level, respectively.

The results in Table 2.6 provide further evidence of cointegration among the variables in the model. The error correction term (i.e. ECM (−1)) has the right sign (negative) and is statistically significant. The estimated values of ECM (-1), which indicates the speed of adjustment to equilibrium following short-run shocks, are -0.8361, -0.7779, -0.7866 and -0.5588 respectively. So about 56%-84% of the

disequilibrium, caused by shocks, is corrected in each period in the converge process to the long-run equilibrium. The ECM models are as follows:

ECM1 = HM1 + 0.2494*EE + 0.0553*ID - 0.0301*SI - 19.8400 *RC - 0.6921*VIX + 22.2064*C -0.0014*T

ECM2 = HM2 + 0.3033 *EE - 0.2574*ID - 0.7326*SI - 24.6484*RC + 0.1133*VIX + 26.2675 *C + 0.0034*T

ECM3 = HM3 + 0.2956 *EE – 0.2330*ID – 0.7471*SI – 25.0766*RC + 0.0946*VIX + 26.8140*C + 0.0020*T

ECM4 = HM4 + 0.3620 *EE – 0.3795*ID – 0.8405*SI – 4.3187*RC + 0.3164*VIX + 4.7668*C + 0.0144*T

Overall, our results suggest that the selected variables are quite appropriate. We conclude that the evidence so far shows that the expected exchange rate appreciation is a robust factor driving hot money flows, independent of how we measure hot money flows. However, the significance of our indicators of the real estate and stock markets, and the VIX depends on the choice for a particular measure of hot money.

2.6 Are the determinants of hot money time varying?

The introduction of several regulations and reforms as described in Section 2.2, may have affected the determinants of hot money flows. We consider the influence of the QFII system (July, 2003), the exchange rate policy reform (July, 2005), the regulation on foreign investment in the real estate market (July, 2006), as well as the global financial crisis (September, 2008). Table 2.7 provides the estimated long-run coefficients based on selected ARDL models in which we add interaction terms of dummies for the launch of QFII system, the reform of the exchange rate policy, the regulation on foreign investment in the real estate market, and the start of the global financial crisis and the determinants possibly affected by these reforms. The dummies are one after the reform, and zero before.

Columns (2)-(4) in Table 2.7 introduce an interaction term of the dummy for the introduction of the QFII system and the stock market index (Dummy1=0 before June 2003, Dummy1=1 after July 2003). The dummy tests for the influence of the launch

of the QFII system which relaxed foreign exchange controls for China's stock market on the relationship between hot money flows and the change of the stock market index. Under the QFII scheme, foreign investors are allowed to invest in 'A' shares[17], bonds and warrants listed on China's domestic stock exchanges, securities investment funds and other instruments permitted by the China Securities Regulation Commission. The scheme allows a single QFII to hold up to 10 per cent of the 'A' shares in one listed company while the total foreign shareholding held by a QFII in any one listed company cannot exceed 20 per cent. The accumulated investment quota for a single QFII is currently capped at US$1 billion. The results show that the coefficient of the interaction term of Dummy1*Change of stock market index and the coefficient of the Dummy1 are not significant when we use the last three measures, suggesting that the launch of QFII did not affect the relationship between hot money flows and the stock market index. We drop the first measure since the bound tests show that these those variables we considered which could drive hot money flows do not have a long-run relationship. QFII requires foreign investors to get approval by State Administration of Foreign Exhange before entering the securities market in China. Only the approved amount of foreign asset can be converted to Reminbi, which can be invested in Chinese stock market through strict supervision[18]. The strict regulation of QFII has not affect the relationship between hot money flows and the stock market index.

Columns (5)-(8) provide the results for testing the effect of the exchange rate policy reform in July 2005 on the relationship between hot money flows and expected depreciation. An interaction term of the dummy and the change of the expected depreciation is introduced (Dummy2=0 before June 2005, Dummy2=1 after July 2005). Again, the coefficients of the interaction term and the dummy are not significant, irrespective of the hot money measure used. Our results therefore do not confirm that the impact of speculating on an exchange rate appreciation on hot money flows changed after the exchange rate became more flexible, thereby not providing support for the views of Ghosh et al. (2012). Our results also do not support the view

[17] 'A' shares are specialized shares that are traded on the Shanghai and Shenzhen stock exchanges.
[18] Acoording to Management of Qualified Foreign Institutional Investors published by China securities regulatory commission, the people's bank of China and state of Administration of foreign exchange.

of Corbo and Hernandez (1996), who argue that a more flexible exchange rate system may lead to excessive volatility in hot money.

Columns (9) and (10) give the results for testing the influence of the regulation on foreign investment in the real estate market in 2006M7 on the relationship between the change of house prices and hot money flows. We incorporate an interaction term of the dummy and the real estate climate index (Dummy3=0 before June 2006, Dummy3=1 after July 2006). It is clear from the results that the dummy terms and the interaction term are significant when we use the second and third measures of hot money as the dependent variable. We drop the first and the fourth measure since the bound tests show that those variables we considered which could drive hot money flows do not have a long-term relationship. So our results suggest that the regulation which aimed at restricting hot money inflows to the real estate market is effective. The hot money inflows significantly decreased after the regulation.

The results for testing the influence from the global financial crisis (2008M9) are presented in columns (11) and (12) of Table 2.7. A dummy (Dummy4=0 before August 2008, Dummy4=1 after September 2008) is included. The bound tests for our first and fourth measures of hot money suggest that there is no long-run relationship among the variables we investigated. The results for the other measures show that the dummy term is significant at the 1% level, suggesting that hot money inflows significantly increased after the start of the global financial crisis.

Table 2.7 Estimated long-run coefficients

(with interaction terms of reform and crisis dummies and determinants)

	Dummy1 2003M7			Dummy2 2005M7			
	HM2	HM3	HM4	HM1	HM2	HM3	HM4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Expected depreciation	-0.2932**	-0.2827**	-0.357**	-0.1896	-0.3901	-0.3964	-0.3220
	(0.1122)	(0.1107)	(0.1592)	(0.2127)	(0.2423)	(0.2392)	(0.2272)
Interest rate differential	0.2706	0.2480	0.3778	0.0836	0.5457*	0.5277*	0.5694**
	(0.1897)	(0.1873)	(0.2542)	(0.2650)	(0.2875)	(0.2838)	(0.2696)
Stock market index	0.4422	0.3421	0.4762	0.1339	0.7064	0.7312*	0.6143
	(2.5019)	(2.4712)	(3.3328)	(0.3979)	(0.4438)	(0.4381)	(0.4162)
Real estate climate index	23.3948	23.5409*	3.8536	22.5687*	21.6781	21.9733	15.9324
	(14.3593)	(14.1777)	(20.6731)	(13.1791)	(13.7049)	(13.5238)	(12.8629)
VIX	-0.1049	-0.0855	-0.3210	0.3830	-0.2109	-0.1941	-0.2696
	(0.3831)	(0.3784)	(0.5148)	(0.4203)	(0.3780)	(0.3732)	(0.3545)
Dummy1*Stock market index	0.3408	0.4681	0.3888				
	(2.5771)	(2.5455)	(3.4413)				
Dummy2*Expected depreciation				0.0957	0.1124	0.1306	0.0764
				(0.2616)	(0.2817)	(0.2781)	(0.2642)
Constant	-24.4515	-24.4994	-3.6218	-23.8786*	-21.8526	-22.2449	-15.7901
	(16.0672)	(15.8655)	(23.0863)	(14.2279)	(14.6273)	(14.4341)	(13.7285)
Trend	-0.0073	-0.0068	-0.0155	-0.0180	-0.0401	-0.0398	-0.0372
	(0.0194)	(0.0192)	(0.0264)	(0.0302)	(0.0331)	(0.0326)	(0.0310)
Dummy1	-0.2611	-0.4120	-0.5969				
	(4.5155)	(4.4601)	(6.0233)				
Dummy2				1.6263	2.7871	2.8681	2.3405
				(2.0738)	(2.3051)	(2.2754)	(2.1616)

Note: The dependent variable is hot money flows. The standard errors are shown in parentheses. *, **, and *** means significant at the 10%, 5%, and 1% level, respectively.

Table 2.7 continued

	Dummy3 2006M7		Dummy4 2008M9	
	HM2 (9)	HM3 (10)	HM2 (11)	HM3 (12)
Expected depreciation	-0.303***	-0.2960***	-0.3718***	-0.3615***
	(0.1040)	(0.1028)	(-3.4764)	(0.1060)
Interest rate differential	0.4714**	0.4451**	0.1084	0.0901
	(0.2053)	(0.2030)	(0.6412)	(0.1676)
Stock market index	0.3943	0.4074	1.0783*	1.0816***
	(0.5334)	(0.5276)	(2.8193)	(0.3793)
Real estate climate index	-20.8882	-19.7598	28.1206**	28.3598**
	(28.5596)	(28.2496)	(2.1603)	(12.9055)
VIX	-0.1779	-0.1600	-0.7276*	-0.6855*
	(0.3755)	(0.3714)	(-1.9186)	(0.3761)
Dummy3*Real estate climate index	55.4565*	54.5607*		
	(30.9685)	(30.6347)		
Dummy4*VIX				
Constant	22.1278	20.8625	-27.8343**	-28.2656**
	(29.9974)	(29.6716)	(-2.0410)	(13.5204)
Trend	-0.0205	-0.0192	-0.0375**	-0.0348**
	(0.0207)	(0.0205)	(-2.3476)	(0.0158)
Dummy3	-55.5879*	-54.6550*		
	(31.6304)	(31.2892)		
Dummy4			3.9124***	3.7528***
			(2.7440)	(1.4137)

Note: The dependent variable is hot money flows. The standard errors are shown in parentheses. *, **, and *** means significant at the 10%, 5%, and 1% level, respectively.

The error correction terms have the right sign (negative) and are statistically significant, which confirms the evidence of cointegration among the variables in the model.

2.7 Conclusions

In this chapter we apply Autoregressive Distributed Lag (ARDL) models to establish which factors are related to hot money flows from January 2000 to December 2012 to China. Our findings suggest that hot money flows are related to the expected appreciation of the Renminbi, independent of our measurement of hot money. Likewise, the interest differential always turns out to be insignificant. However, the

significance of the stock market index, the real estate climate index and the VIX depends on our measurement of hot money. In all, the choice of the measure for hot money does matter for the significance of its determinants.

The expected depreciation of the RMB was a crucial factor driving hot money flows in China. Its coefficient is consistently significant with a negative sign. The exchange rate policy reform in 2005 had no significant impact on this relationship. The relationship between the stock market index and hot money flows are positive, and have not significantly been affected by the QFII system. The regulation of foreign investment in the real estate market had a significant effect on hot money flows. Our results suggest that the levels of China's hot money flows are sensitive to the financial crisis. The hot moneys flow to China were significantly higher after the global financial crisis for two of our measures of hot money. This result is in accordance with the findings of Fratzscher (2012) who reports that external factors were overall the main drivers of capital flows during the crisis.

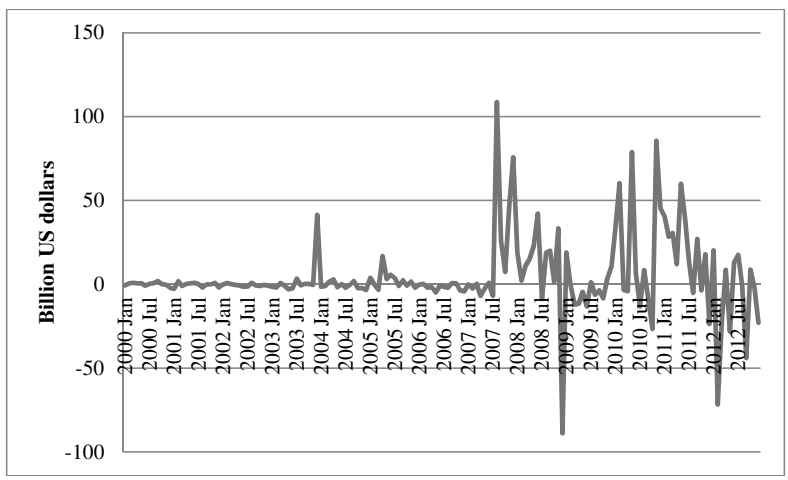
The ARDL model is a more appropriate methodology when investigating the determinants of capital flow since it does not require all variables to be either I(0) or I(1). Our results complement those of Cheung and Qian (2010b) and show that the relevance of the drivers of hot money in China to some extent depends on the precise definition of hot money. We expect this result to be generalized. It is recommended that an explicit measurement of hot money should be given while using the expression "hot money".

Appendix

2.A Calculating adjusted foreign reserves

1. China's foreign exchange reserves mainly consist of assets denominated in US dollar, euro and yen. Foreign reserves are published in US dollars. In case the US dollar depreciates, the dollar value of assets denominated in other currencies will appreciate, so the stock of foreign reserves in dollars will increase. We assume that since 2000, China's foreign exchange reserve currency structure remains the same, i.e. the US dollar, euro and yen assets account for 70%, 20% and 10%, respectively (Zhang and Xu, 2008) and we adjust the stock of foreign reserves for currency fluctuations accordingly. The adjustment of the foreign exchange reserves is shown in Figure 2.A.1.

Figure 2.A.1. The monthly adjustment of the foreign exchange reserves



2. China Investment Corporation (CIC) is a sovereign-wealth fund which was established in September 2007. CIC received 200 billion USD, funded by special government bonds. These were recorded as capital account outflow transactions in the BOP statistics. From August 2007 to December 2007, the Ministry of Finance issued eight special treasury bonds with a total amount of 15 trillion RMB. We assume that the Ministry of Finance buys foreign currency on the day when they issue special treasury bonds. From August 2007 to December 2007, the central bank set aside

totally 207.9 billion US dollars from foreign exchange reserves. Taking into account that the CIC has paid 67 billion US dollars to the Chinese central bank in the acquisition of Central Huijin, the net amount CIC obtained from the central bank's foreign exchange reserves is 140.9 billion US dollars. We add these special bonds to the foreign reserves, and subtract the amount the CIC paid to the central bank.

Table 2.A.1 Special bonds issued from Ministry of Finance

Number	Time	Amount in RMB	Exchange rate	Amount in US dollar (billion)
1	Aug 2007	6000.0	7.5505	79.47
2	Sep 2007	1033.8	7.5050 ~ 7.5230	13.76
3	Nov 2007	705.3	7.4336 ~ 7.4624	9.47
4	Dec 2007	7763.5	7.3790 ~ 7.3797	105.20

Source: Zhang and Xu (2008).

3. The Chinese central bank injected funds through Central Huijin to state-owned commercial banks and securities companies in order to assist reforms of these banks and companies. Central Huijin is an investment company owned by the government of the People's Republic of China (PRC). In order to improve corporate governance and initiate reforms of the banking sector, the PRC government operate Huijin as a shareholder for the large "big four" state owned banks (Zhang and He, 2009). Most of these funds are in foreign currency. Central Huijin was established in December 2003. The injected funds are shown in Table 2.A.2. We add these injections to the foreign reserves.

Table 2.A.2 Injected funds by Central Huijin

Institution	Date	Amount	Note
Bank of China	Dec, 2003	22.5 billion US dollars	
China Construction Bank	Dec, 2003	20 billion US dollars	
China Jianyin Investment	Dec, 2003	2.5 billion US dollars	
Bank of Communications	Jun, 2004	3 billion Chinese Yuan	0.36 billion US dollars On loan
Industrial and Commercial Bank of China	Apr, 2005	15 billion US dollars	
China Galaxy Securities	Jun, 2005	10 billion Chinese Yuan	1.21 billion US dollars
The Export-Import Bank of China	Jul, 2005	5 billion US dollars	
Shenyin & Wanguo Securities	Aug, 2005	2.5 billion Chinese Yuan	0.31 billion US dollars +1.5 billion loan in Chinese Yuan
Guotai Junan Securities	Aug, 2005	1 billion Chinese Yuan	0.12 billion US dollars +1.5 billion loan in Chinese Yuan
China Galaxy Financial Holdings	Aug, 2005	5.5 billion Chinese Yuan	0.68 billion US dollars
China Everbright Bank	Sep, 2005	10 billion Chinese Yuan	1.24 billion US dollars
China Investment Securities	Sep, 2005	0.35 billion Chinese Yuan	0.04 billion US dollars Restructure Nanfang Securities, rename as CIS +8.7 billion loan in Chinese Yuan
China Everbright Bank	Nov, 2007	20 billion US dollars	
Industrial and Commercial Bank of China	Sep, 2008	4.15*2=8.3 million Chinese Yuan	Buy 2 million share in each bank
China Construction Bank		4.55*2=9.1 million Chinese Yuan	25.8 million Chinese Yuan=3.77 million US dollars
Bank of China		3.7*2=7.4 million Chinese Yuan	
Agriculture Bank of China	Nov, 2008	130 billion Chinese Yuan	19.04 billion US dollars
China Construction Bank	From 23, Sep, 2008 to 28, Nov, 2008	4.55*5.08=23.1 million Chinese Yuan	Totally 7.08 million share minus 2 million on 23, Sep, 2008 3.37 million US dollars
China Development Bank	Dec, 2008	20 billion US Dollars	Restructure
China Export & Credit Insurance Corporation	Dec, 2012	20 billion Chinese Yuan	3.2 billion US dollars

Source: Wikipedia, http://zh.wikipedia.org/wiki/%E4%B8%AD%E5%A4%AE%E6%B1%87%E9%87%91%E6%8A%95%E8%B5%84%E6%9C%89%E9%99%90%E8%B4%A3%E4%BB%BB%E5%85%AC%E5%8F%B8.

4. The People's Bank of China started requesting major banks to submit deposit reserves in US dollars since August 2007. On the balance sheet of the PBOC, foreign currency deposits from banks were recorded under "other foreign assets", rather than

"foreign exchange reserves". We first calculate the amount of the funds which have been frozen/released when the reserve ratio changes. Since not every commercial bank was subject to the requirements of deposit reserve in US dollars, we use the ratio of 70% as suggested by Zhang and Xu (2008). We convert these frozen/released amounts into US dollars and add/abstract the amounts to the foreign reserves.

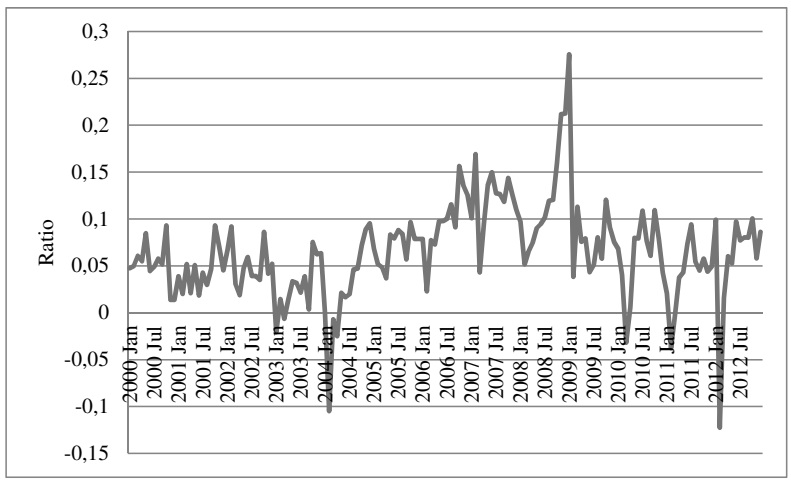
Table 2.A.3 Estimate of deposit reserves of commercial banks

Date	Deposits (hundred million Yuan)	Deposit rate	Frozen or released (hundred million Yuan)	70% of frozen or released	Exchange rate (RBM to US dollars)	Amount in US dollars (billion)
2007 Aug	377415.9	0.12	1887.080	1320.956	7.576	17.436
2007 Sep	382981.2	0.125	1914.906	1340.434	7.516	17.834
2007 Oct	378483.7	0.13	1892.419	1324.693	7.513	17.633
2007 Nov	385507.2	0.135	1927.536	1349.275	7.425	18.171
2007 Dec	389371.1	0.145	3893.711	2725.598	7.372	36.975
2008 Jan	391551.5	0.15	1957.757	1370.430	7.252	18.898
2008 Mar	415693.1	0.155	2078.466	1454.926	7.089	20.523
2008 Apr	422275	0.16	2111.375	1477.963	6.999	21.117
2008 May	431274	0.165	2156.370	1509.459	7.003	21.554
2008 Jun	438989.3	0.175	4389.893	3072.925	6.902	44.524
2008 Oct	458331.5	0.17	-2291.657	-1604.160	6.839	-23.456
2008 Dec	466203.3	0.155	-6993.050	-4895.135	6.843	-71.538
2010 Jan	612877.3	0.16	3064.386	2145.070	6.827	31.419
2010 Feb	622436.8	0.165	3112.184	2178.529	6.833	31.882
2010 May	660756.8	0.17	3303.784	2312.649	6.827	33.876
2010 Nov	708784.3	0.18	7087.843	4961.490	6.637	74.755
2010 Dec	718237.9	0.185	3591.190	2513.833	6.655	37.773
2011 Jan	712828.1	0.19	3564.140	2494.898	6.590	37.859
2011 Feb	726017.6	0.195	3630.088	2541.062	6.597	38.521
2011 Mar	752838.4	0.2	3764.192	2634.934	6.570	40.107
2011 Apr	756262.4	0.205	3781.312	2646.918	6.532	40.525
2011 May	767339	0.21	3836.695	2685.687	6.498	41.333
2011 Jun	786432.6	0.215	3932.163	2752.514	6.480	42.475
2012 Dec	809368.3	0.21	-4046.842	-2832.789	6.371	-44.467
2012 Feb	817398.1	0.205	-4086.990	-2860.893	6.300	-45.414
2012 May	854499.7	0.2	-4272.498	-2990.749	6.322	-47.311

Source: The People's Bank of China.

2.B Hot money in trade invoicing

Figure 2.B The ratio of trade surplus to total trade in China



Note: Trade surplus is calculated from substracting Goods, Value of Imports from Goods, Value of Exports. Total trade is calculated from summing Goods, Value of Imports and Goods, Value of Exports. The average ratio of trade surplus to total trade in the period January 2000 to July 2005 is 0.0413. If the ratio in a month is higher than this baseline, the hot money in trade invocing flows in China. If the ratio in a month is lower than this baseline, the hot money in trade invocing flows out of China.

2.C Error correction representation of the selected ARDL model (with interaction terms of reform and crisis dummies and determinants)

	HM2	HM3	HM4	HM1	HM2	HM3	HM4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
D(Hot money (-1))			-0.3189***				
			(0.1042)				
D(Hot money (-2))			-0.1914**				
			(0.0816)				
D(Expected depreciation)	-0.2282***	-0.2226**	-0.1993**	-0.1486	-0.3067	-0.3154*	-0.2644
	(0.0858)	(0.0857)	(0.0822)	(0.1666)	(0.1902)	(0.1901)	(0.1861)
D(Interest differential)	0.2106	0.1953	0.2109	0.0655	0.4290*	0.4199*	0.4676**
	(0.1475)	(0.1473)	(0.1422)	(0.2073)	(0.2266)	(0.2264)	(0.2225)
D(Stock market index)	0.3442	0.2694	0.2658	0.1049	0.5553	0.5818	0.5045
	(1.9470)	(1.9457)	(1.8631)	(0.3118)	(0.3545)	(0.3547)	(0.3461)
D(Real estate climate index)	109.8051***	108.5057**	98.6328**	17.6832*	112.6728***	111.5457***	120.4446***
	(41.5936)	(41.5439)	(40.3632)	(10.4637)	(41.4576)	(41.4041)	(40.8259)
D(VIX)	-0.0817	-0.0673	-0.1792	-1.815***	-0.1658	-0.1545	-0.2214
	(0.2987)	(0.2984)	(0.2867)	(0.4934)	(0.2982)	(0.2979)	(0.2924)
D(VIX(-1))				-1.3592**			
				(0.5338)			
D(VIX(-2))				0.5242			
				(0.4897)			
D(VIX(-3))				-2.4801***			
				(0.4801)			
D(DM1)	0.2652	0.3686	0.2170				
	(2.0063)	(2.0053)	(1.9188)				
D(DM2)				-0.2020	0.0883	0.1039	0.0627
				(0.2018)	(0.2216)	(0.2215)	(0.2171)
D(Constant)	-19.0301	-19.2916	-2.0217	-18.7095	-17.1783	-17.6993	-12.9682
	(12.8619)	(12.8481)	(13.0504)	(11.2979)	(11.8456)	(11.8366)	(11.5098)
D(Trend)	-0.0057	-0.0054	-0.0087	-0.0141	-0.0315	-0.0317	-0.0306
	(0.0151)	(0.0151)	(0.0145)	(0.0236)	(0.0260)	(0.0260)	(0.0255)
D(M1)	-0.2032	-0.3244	-0.3332				
	(3.5148)	(3.5129)	(3.3595)				
D(M2)				1.2743	2.1910	2.2820	1.9222
				(1.6161)	(1.8165)	(1.8160)	(1.7782)
ECM (-1)	-0.7783***	-0.7874***	-0.5582***	-0.7835***	-0.7861***	-0.7957***	-0.8213***
	(0.0801)	(0.0804)	(0.1145)	(0.0765)	(0.0799)	(0.0802)	(0.0802)
R-Squared	0.4182	0.4216	0.4734	0.6068	0.4245	0.4280	0.4423

R-Bar-Squared	0.3769	0.3806	0.4279	0.5666	0.3836	0.3875	0.4028
F-stat.	11.2606***	11.4209***	11.3573***	17.6174***	11.5539***	11.7242***	12.4264***

Notes: The dependent variable is the first difference of hot money flows. ECM denotes error correction term obtained from the long-run relationship. The standard errors are shown in parentheses. *, **, and *** means significant at the 10%, 5%, and 1% level, respectively.

2.C continued

	HM2	*HM3*	*HM2*	*HM3*
	(9)	(10)	(11)	(12)
D(Expected depreciation)	-0.2435***	-0.2403***	-0.2992***	-0.2934***
	(0.0815)	(0.0815)	(0.0850)	(0.0850)
D(Interest differential)	0.3787**	0.3613**	0.0872	0.0731
	(0.1659)	(0.1656)	(0.1359)	(0.1359)
D(Stock market index)	0.3168	0.3308	0.8677***	0.8779*
	(0.4322)	(0.4321)	(0.3165)	(0.3169)
D(Real estate climate index)	82.5293*	81.4077*	22.6284**	23.0188**
	(44.7887)	(44.7616)	(10.9689)	(10.9723)
D(VIX)	-0.1429	-0.1299	-0.5855*	-0.5564*
	(0.3022)	(0.3020)	(0.3093)	(0.3088)
D(DM3)	44.5549*	44.296*		
	(25.3711)	(25.3499)		
D(Constant)	17.7779	16.9375	-22.3980*	-22.9424**
	(24.0869)	(24.0754)	(11.4573)	(11.4652)
D(Trend)	-0.0164	-0.0156	-0.0302**	-0.0283**
	(0.0165)	(0.0165)	(0.0128)	(0.0128)
D(M3)	-44.6603	-44.3725*		
	(25.9230)	(25.9004)		
D(M4)			3.1483***	3.0460**
			(1.1646)	(1.1633)
ECM (-1)	-0.8034***	-0.8119***	-0.8047***	-0.8117***
	(0.0809)	(0.0811)	(0.0802)	(0.0805)
R-Squared	0.4316	0.4348	0.4256	0.4279
R-Bar-Squared	0.3913	0.3947	0.3935	0.3959
F-stat.	11.8964***	12.0495***	13.2449***	13.3702***

Notes: The dependent variable is the first difference of hot money flows. ECM denotes error correction term obtained from the long-run relationship. The standard errors are shown in parentheses. *, **, and *** means significant at the 10%, 5%, and 1% level, respectively.

Chapter 3

Sudden Stops and Currency Crashes

3.1 Introduction

In a world with high capital mobility, the threat of sudden stops and currency crashes is a key issue in international finance and economics (Obstfeld and Taylor, 2004; Rothenberg and Warnock, 2011). A sudden stop refers to an episode with a sharp contraction in international capital inflows (Calvo et al., 2004). A currency crash refers to a period with a large drop of the nominal exchange rate that is accompanied by a substantial increase in the rate of depreciation (Frankel and Rose, 1996). Although some studies (e.g. Radelet et al., 1998; Milesi-Ferretti and Razin, 2000) use sudden stops and currency crises interchangeably, it should be clear from these definitions that sudden stops and currency crashes are not identical.

Sometimes sudden stops occur simultaneously with currency crashes. Prominent examples are the crises in Mexico (1994), Brazil (1998), and Argentina (2001). According to Calvo and Mishkin (2003), between 1992 and 2001 twelve sudden stops in emerging economies were associated with devaluations. In eight cases, a sudden stop occurred first and was followed by devaluation, while in four cases devaluation was followed by a sudden stop. Likewise, Calvo et al. (2004) provide evidence that capital flow reversals mostly precede depreciations. Their sample includes 15 emerging economies and 17 advanced economies during the 1990-2001 period. Using a dataset on capital inflows spanning 16 economies from 1870 to 1914, Catão (2007) concludes that currency crashes are either concomitant with sudden stops or follow sudden stops with a one- or two-year lag. However, in other circumstances, currencies can be invariant to the turmoil of sudden stops. Hutchison and Noy (2006) find that it is not uncommon to have capital flow reversals without currency crashes.

Efremidze et al. (2011) examine several sudden stops and currency crises from 1990 to 2003 for 25 emerging markets. They find that less than half of the sudden stops are accompanied by currency crises, while less than 60 percent of the currency crises coincide with sudden stops. In general, sudden stops appear to precede currency crises. Using a sample from 1880 to 1913, Bordo et al. (2010) report that about 40 percent of the sudden stops are followed by a financial crisis (debt, currency or banking crisis) within three years. These results suggest that several economies have gone through sudden stops without facing currency crashes. In sum, sharp reductions in international capital inflows are not automatically followed by severe depreciations.

The current international financial crisis saw an unprecedented collapse in international capital flows (Milesi-Ferretti and Tille, 2011). Several economies, such as Iceland, Russia, Romania, and the Ukraine, suffered severely from sudden stops. Since sudden stops followed by currency crashes lead to higher output losses than sudden stops without devaluations (Shankar, 2007; Sula and Willett, 2009; Efremidze et al. 2011), it is important to identify the factors that determine whether sudden stops are concomitant with or followed by currency crashes. That is the first purpose of our research. To this extent, we identify sudden stops on the basis of Calvo et al. (2004) and group them in two major categories: sudden stops followed by a currency crash and those not followed by a currency crash.

We employ two complementary methodologies to explore the data. First, we use an event study approach inspired by Gourinchas and Obstfeld (2012). Secondly, we estimate a logit model inspired by Frankel and Rose (1996). We examine whether the two types of crisis are driven by different factors. The second purpose of this chapter is to investigate the role of the exchange rate regime in place. The latter is motivated by Lane and Milesi-Ferretti (2012) who argue that the impact of a sudden stop differs across exchange rate regimes, because a country with a fixed exchange rate regime is

unable to offset the domestic demand shock through expansionary monetary policy and/or accomplish real exchange rate adjustment through nominal depreciation. We examine whether the drivers of both types of crisis differ across different exchange rate regimes.

Our results suggest that low trade openness, shallow financial development, and current account imbalances increase the likelihood that a sudden stop will be followed by a currency crash. In addition, our results suggest that the exchange rate regime in place matters. More specifically, the current account plays a role in the three types of exchange rate regime that we distinguish (i.e. hard pegs, other pegs and intermediate regimes). Budget deficits are significant in hard pegs, while trade openness plays a role in both hard and other pegs. The first generation currency crisis models (Krugman, 1979) explains the channels through which fiscal imbalances affect the exchange rate. Countries are prone to currency crisis when government expenditures grow faster than the government revenue during reserve losses and real exchange rate appreciations, the latter is more serious when the trade openness is less. Financial development is essential in both other pegs and intermediate regimes. This evidence verifies the findings of Whale (1937) and Ford (1962) regarding the importance of the domestic financial imperfections in propagating capital account shocks and accounting for cross-country differences in macroeconomic adjustment.

The remainder of this chapter is structured as follows. Section 3.2 presents a review of the literature review on how sudden stops are related to currency crashes. Section3.3 defines and analyzes the variables used in our analysis. Sections 3.4 and 3.5 present the empirical results, while Section 3.6 analyses the role of the exchange rate regime. Section 3.7 concludes.

3.2 How are sudden stops related to currency crashes?

There is an impressive amount of literature on currency crashes (see Frankel and George (2010) for a recent overview) but only a few studies relate to both sudden stops and currency crashes. We will discuss these studies to identify variables to be included in our empirical analysis.

Calvo (1998) studies the mechanisms through which a sudden stop in international credit flows may bring about financial and balance of payment crises. A slowdown in capital inflows is typically associated with an increase in domestic interest rates. If the central bank tries to cushion the increase in interest rates, the stock of high-powered money will increase, which, in turn may cause downward pressure on the exchange rate.

Gourinchas and Obstfeld (2012) argue that unless the country can draw on official foreign exchange reserves or relatively liquid assets held abroad by the private sector, sudden stops typically will be associated with currency crashes. However, there is a difference between fixed and floating exchange rate regimes, because the exchange rate interventions by the central bank differ. Under a hard peg, the central bank will defend the exchange rate when capital inflows reverse. The defense mechanisms used include running down on its reserves and increasing the short-term interest rate (Eichengreen et al., 1995). If an economy has a high level of reserves, a reversal in capital inflows will not induce devaluation because the central bank can defend the currency successfully by running down the country's reserves (cf. Lucas, 1990 and Drazen, 1999). By increasing the short-term interest rates, the reversal of capital flows may be stopped. However, Radelet et al. (1998) doubt the effectiveness of increasing interest rates for stabilizing the currency in case of a panic. As shown by Flood and Jeanne (2005), interest rate increases can be successful only if fiscal policy is sustainable, as the increase of the interest rate will increase the government's budget deficit. In all, it appears that the level of international currency

reserves is one of the factors that may determine whether sudden stops are followed by currency crashes in hard pegs (Cowan et al., 2008). Furthermore, the effectiveness of increasing the short-term interest rate depends on whether the country's fiscal policy is sustainable. If the government has a large fiscal deficit, there is no room to use fiscal policy to combat external shocks (Catão, 2007).

In contrast to fixed exchange rate regimes, a sudden stop is a contractionary shock in freely floating exchange rate regimes. Here, a sudden stop immediately drives down the exchange rate because the government is not obliged to stabilize the currency in freely floating regimes. An economy's ability to absorb a sudden decline in capital inflows depends on its level of financial development (Cowan et al., 2008). Catão (2007) gives the following explanation: Firstly, in case of shallow domestic bond markets a decline in capital inflow reduces firms' access to finance. Secondly, illiquid domestic markets exacerbate the risk of fire sales and bank runs in the wake of sudden stops. Catão (2007) finds that economies with seemingly better-regulated banks and deeper financial markets are better able to successfully manage a sudden stop while keeping their currency pegs.

In sum, the determinants of sudden stops leading to currency crashes can be classified as: trade openness (Calvo, 1998; Cowan et al., 2008), financial sector development (Catão, 2007; Cowan et al., 2008), current account imbalances (Milesi-Ferretti, 2000), level of foreign reserves (Catão, 2007; Cowan et al., 2008), and monetary and fiscal policies (Flood and Jeanne, 2005; Catão, 2007). In addition, the exchange rate regime plays a role. In the following sections, we define proxies for these variables and use both the event study approach and logit models to determine whether the impact of the variables affecting sudden stops followed by a currency crash differs across exchange rate regimes.

3.3 Data

Several approaches have been used to define sudden stops. As the definitions suggested by Edwards (2004a, 2004b, 2005), Efremidze and Tomohara (2011), Sula (2010) and Guidotti et al. (2004) are only applicable to annual data, we follow Calvo et al. (2004) and identify a sudden stop as a phase that meets the following conditions. First, it contains at least one observation where the year-on-year fall in capital inflows is at least two standard deviations below the sample mean. Second, the sudden stop phase ends once the annual change in capital inflows exceeds one standard deviation below the sample mean. For the sake of symmetry, the start of a sudden stop phase is determined by the first time the annual change in capital inflows falls one standard deviation below the mean. In addition, Calvo et al. (2004) apply a requirement for output contraction to identify sudden stops, which is also widely used (Calvo et al. 2008; Durdu et al. 2009; Bordo et al. 2010). Since we intend to capture episodes of net capital inflow contractions, we do not require GDP contractions to characterize sudden stop events.

Several methods have been used to identify currency crashes[19]. We employ the widely used approach as suggested by Frankel and Rose (1996), who define a currency crash as an annual nominal depreciation of at least 25 percent of the currency which is also at least a 10 percent increase in the rate of depreciation. However, instead of using the bilateral US dollar exchange rate, we use the SDR exchange rate to mitigate the influence of the US dollar on currency fluctuations (see also Rose and Spiegel 2011, and Gagnon, 2009).

[19] For instance, Gagnon (2010) qualifies an exchange rate depreciation exceeding 15 percent in four quarters as a currency crash provided the depreciation does not exceed 15 percent in any of the previous four quarters, while Fratzscher et al. (2011) identify a currency crash by using the criterion that the annual rate of depreciation of the real effective exchange rate exceeds 10 percent.

We use monthly data for the January 1980 to December 2008 period from the IMF's International Financial Statistics. We construct net capital flows by netting out the trade balance from changes in foreign reserves. For 85 economies we have data on capital flows for at least 5 years. We find that there are 158 occasions of sudden stops in these economies (see Appendix 3.A). Thus, on average, in the past thirty years, each economy has experienced about two sudden stops. Since we have to identify whether there is a currency crash during the 36 months following a sudden stop, we use data on currency crashes from January 1980 to December 2010. We employ changes in the end-of-period monthly home currency per SDR to identify currency crashes. For 16 out of the 158 sudden stops we lack appropriate data. Among the remaining 142 sudden stops, 52 are followed by currency crashes in the following 36 months, and 90 of them are not followed by currency crashes. Thus, in our sample, 36.6 percent of the sudden stops precede currency crashes. These findings are similar to those of Efremidze et al. (2011) and Bordo et al. (2010).

Using the criteria of the IMF to classify economies, there are 23 advanced economies in our sample (see notes in Appendix 3.A for the classification). These economies have 47 sudden stops in the 1980-2008 periods (see Table 3.1). However, there are only eight sudden stops with currency crashes in this subsample. Thus, the ratio of advanced economies having sudden stops with currency crashes is 17 percent. This is significantly lower than the ratio for less advanced economies (46.3 percent). These characteristics are in line with the findings of Catão (2007). They are also consistent with the consensus view that less advanced economies are more vulnerable to a financial crisis because of mutually reinforcing structural weaknesses (Gourinchas and Obstfeld, 2012), such as faulty governance structures, overregulated markets, extensive dollarization of domestic and external liabilities, and "fear of floating" (Calvo and Reinhart, 2002). According to Cowan et al. (2008), a country's ability to absorb shocks due to lower capital inflows depends on its level of financial

development and its stock of gross international assets. The more advanced economies are in a better position to deal with financial shocks along both dimensions.

Table 3.1 Sudden stops with/without currency crash in advanced and less advanced economies

Sudden stops:	Advanced economies	Less advanced economies	Total
followed by currency crash	8 (17%)	44 (46.3%)	52 (36.6%)
not followed by currency crash	39 (83%)	51 (53.7%)	90 (63.4%)
Total	47	95	142

Note: Advanced economies are listed in the note of Appendix 3.A.

Table 3.2 compares the frequency of sudden stops with and sudden stops without a currency crash in the 1980s, 1990s and 2000s. In the most recent decade, the frequency of sudden stops with a currency crash is 4.8 percent, which is significantly lower than that in the 1980s and 1990s (59.6 and 37.2 percent, respectively).

Table 3.2 Sudden stops with/without currency crash in different decades

Sudden stops:	1980-1989	1990-1999	2000-2008	1980-2008
followed by currency crash	34 (59.6%)	16 (37.2%)	2 (4.8%)	52 (36.6%)
not followed by currency crash	23 (40.4%)	27 (62.8%)	40 (95.2%)	90 (63.4%)
Total	57	43	42	142

Note: 1980-1989 and 1990-1999 include data for 10 years; 2000-2008 include data for 9 years.

As we want to examine whether there are systematic differences across countries having a different exchange rate regime, we need to classify countries according to the exchange rate regime in place. The classification of exchange rate regimes is a controversial issue in international economics. For many years, empirical studies on

exchange rate regimes relied on the IMF's *de jure* classification. However, Calvo and Reinhart (2002) find that, in practice, many exchange rate regimes did not function according to the *de jure* rules. Consequently, several authors have proposed *de facto* classifications[20]. We use the approach suggested by Reinhart and Rogoff (2004) as updated by Ilzetzki et al. (2011), which covers data from 1946 until 2010. This approach is based on market determined exchange rates rather than official exchange rates. There are six categories of exchange rate regimes in this classification scheme (see Appendix 3.B for details). We leave out two categories, namely *Freely falling* and *Dual market in which parallel market data is missing*, as these are not relevant[21] in our sample.

The frequency of sudden stops with a currency crash under a hard peg, other pegs, intermediate regimes (i.e. category 3 in Appendix 3.B) and freely floating exchange rate regimes are 24.5, 36.7, 20.4 and 20.0 percent, respectively (see Table 3.3). This suggests that countries belonging to the other peg regimes category are most fragile to currency crashes in the face of sudden stops. These results seem to support the "bipolar" view (Fischer, 2001; Eichengreen, 1994), according to which in a world of increasing trade openness and international capital mobility, only the two extreme exchange regimes (hard pegs, such as dollarization, currency boards and monetary unions) or freely floating exchange rates will survive.

[20]According to Alesina and Wagner (2006), the three most commonly used methods in classifying exchange regimes are those from Levy-Yeyati and Sturzenegger (2005), Reinhart and Rogoff (2004) and Shambaugh (2004).

[21] Freely falling is a category for countries with annual inflation rates above 40%. Dual market in which parallel market data is missing is a category with data not available.

Table 3.3 Sudden stops with/without a currency crash in different exchange rate regimes

Sudden stops:	Hard peg	Other peg	Intermediate	Freely floating	Freely falling	Total
followed by	12	18	10	1	7	48
currency crash	(28.6%)	(46.2%)	(26.3%)	(20%)	(100%)	
not followed by	30	21	28	4	0	83
currency crash	(71.4%)	(53.8%)	(73.7%)	(80%)	(0%)	
Total	42	39	38	5	7	131

Note: *de facto* exchange rate regimes before the year of sudden stops (see Appendix 3.B).

Based on the studies discussed in Section 3.2, we identify nine potential determinants of sudden stops with and without currency crashes (see Appendix 3.C for details). Trade to GDP and exports to GDP relate to trade openness.[22] We also include the current account to GDP and financial openness as provided by Lane and Milesi-Ferretti (2007). The inflation rate is our monetary policy indicator, while claims on central government as a share of GDP is our indicator of fiscal policy. The proxies for financial sector development are the ratio of M2 to GDP and domestic credit provided by the banking sector as a percentage of GDP. The international reserves indicator used is total reserves in months of imports.

3.4 Event study approach

In this section, we compare the behavior of these nine variables before and after each of the two types of crises we defined above. Following Gourinchas and Obstfeld (2012) and Balteanu and Fernandez (2011), we use an event study approach, which allows us to control for country characteristics. We estimate the conditional

[22] We also considered the black market premium as a variable for the overvalued exchange rate (Caporale and Cerrato, 2008), but due to lack of sufficient data we could not include it in the analysis.

expectation of y_{it} as a function of the temporal distance from the crisis, relative to a "tranquil times" baseline. y_{it} is the variable of interest and subscript i refers to the country and subscript t to the period. Our estimation considers two types of crisis: sudden stops without currency crashes and sudden stops with currency crashes. The fixed-effects panel specification is as follows:

$$y_{it} = \alpha_{ij} + \beta_{so}\delta_{so} + \beta_{sw}\delta_{sw} + \varepsilon_{it} \quad (3.1)$$

where δ_{sj} denotes a dummy variable equal to 1 when country i is s periods away from a crisis of type j in period t. The index j denotes the crisis type, i.e. a sudden stop without a currency crash ($j=o$) and a sudden stop with a currency crash ($j=w$). We follow Gourinchas and Obstfeld (2012) and set the crisis window to 11 years (5 years before and 5 years after) so as to allow for the adjustment following a crisis. The regression also allows for country fixed effects α_i. The error term ε_{it} captures all the remaining variation.

The coefficients β_{sj} measures to what extent the variable y behaves differently during a crisis of type j relative to "tranquil times" over the event window $-5 \leq s \leq 5$. Since the "tranquil time" baseline is common to both types of crisis, we are measuring the impact of both crises relative to a common level. It shows how the variables we are interested in evolve over different crisis episodes. In particular, a comparison of the β coefficients for both types of crisis shows to what extent the behavior of a variable differs across the two types of crisis. In order to minimize the effect of heterogeneity across countries and to deal with extreme observations, we normalize our variables by subtracting the population mean from the individual raw data and then divide the difference by the population standard deviation. Due to missing data, we have to drop 10 economies. The estimation results are shown in Figures 3.1-3.9.

The results for trade openness, i.e. trade and exports both as share of GDP, are presented in Figures 3.1 and 3.2, respectively. The beginning of a crisis is indicated

by *t*. Figures 3.1-3.2 show that in the years preceding sudden stops without currency crashes, trade openness tends to be higher than in tranquil times. In addition, trade openness is moving upwards before crises. By contrast, in the run up to sudden stops with currency crashes, trade openness is lower relative to tranquil times. The patterns are consistent with the view of Calvo (1998) and Cowan et al. (2008), who argue that the effect of a sudden stop on the real exchange rate will be larger in economies with less openness.

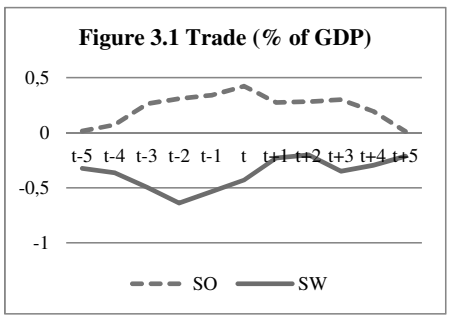
As shown in Figure 3.3, there is a significant improvement in the current account before a sudden stop without a currency crash. In contrast, economies experiencing a sudden stop with a currency crash were mostly running higher current account deficits relative to tranquil times.

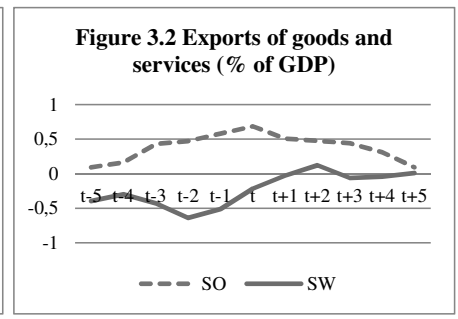
The results for financial sector indicators, which include financial openness, M2 as percentage of GDP and domestic credit provided by the banking sector as a percentage of GDP, are plotted in Figures 3.4-3.6. Figures 3.4-3.6 suggest that economies experiencing sudden stops with a currency crash have lower financial openness and a lower financial development level than economies experiencing a sudden stop without a currency crash. Additionally, both types of crisis are associated with significant prior build-ups in credit relative to GDP, M2 to GDP and financial openness. As such, our results suggest that a booming financial sector is a common feature of both types of crisis. Furthermore, we find that financial development and financial openness are comparatively low in samples with sudden stops followed by currency crashes.

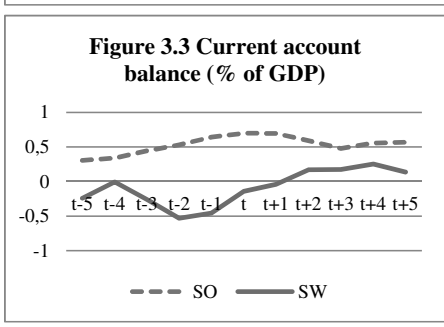
Figure 3.7 reports our findings for inflation. The inflation rate in the case of sudden stops with currency crashes is higher than in sudden stops without currency crashes. Moreover, the inflation rate appears elevated, relative to tranquil times, until three years ahead of sudden stops with currency crashes. However, it is depressed compared to tranquil times, before sudden stops without currency crashes.

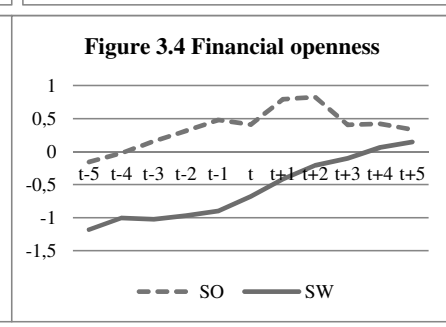
Figure 3.8 reports our results for claims on central government as percentage of GDP. The public finance situation is worse (compared to tranquil times) in both types of crisis. However, the public finance position is deteriorating before sudden stops with currency crashes, whereas it is ameliorating before sudden stops without currency crashes.

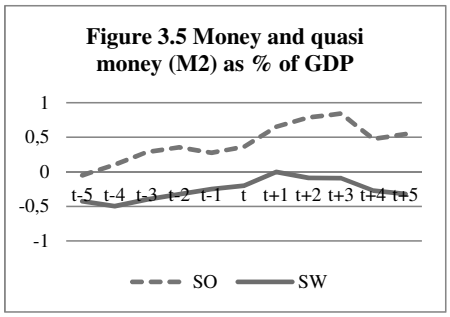
Figure 3.9 shows our findings for reserves. It is clear that the level of reserves is higher in sudden stops without currency crashes compared to sudden stops with currency crashes. In addition, reserves are increasing before sudden stops without currency crashes, but decreasing before sudden stops with currency crashes. This result is in line with the expectation that if a country cannot draw on official foreign exchange reserves, a sudden stop is more likely to be associated with an abrupt currency depreciation.

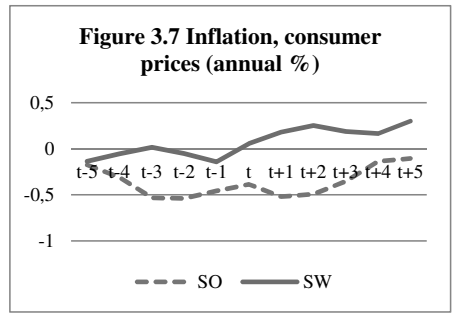


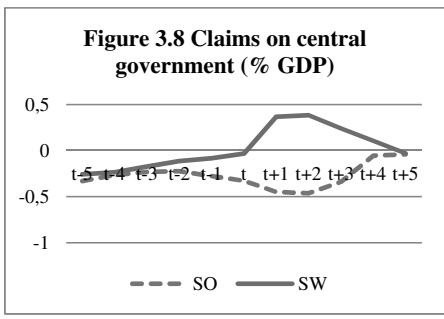


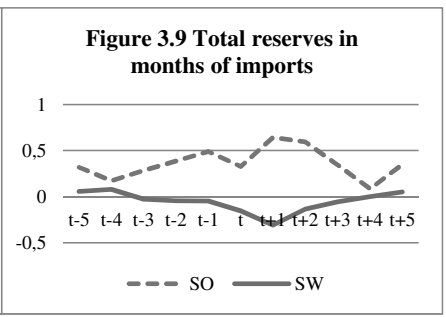












Note: SO = a sudden stop without a currency crash; SW = a sudden stop with a currency crash.

To summarize our findings so far, we observe clear differences in the developments of various indicators between countries which had a sudden stop followed by a currency crash and those which had a sudden stop which was not followed by a currency crash. The latter had a higher level of trade openness, a higher current account surplus, a higher level of financial development and financial openness, less expansionary fiscal and monetary policies, and they had more international reserves.

As explained in Section 3.2, the exchange rate regime may also affect the factors which influence whether or not a sudden stop is followed by a currency crash. In the remainder of this section, we therefore examine developments under different exchange rate regimes.

For three types of exchange rate regimes, we examine whether our variables of interest follow different patterns in the run-up to a sudden stop followed by a

currency crash and in the run-up to a sudden stop without a currency crash compared to tranquil periods. The category of freely floating exchange rates is dropped in our analysis because of data limitations. In total, we have 27 figures (9 variables for three categories of exchange rate regime). Here we only show the results for the four variables for which the results show the largest differences across the three exchange rate regimes considered, i.e. trade to GDP, M2 as percentage of GDP, claims on central government as percentage of GDP, and total reserves in months of imports (The results for the other five variables are shown in Appendix 3.D). Figures 3.10-3.12 show the results for trade of GDP for hard pegs, other pegs and intermediate regimes separately, Figures 3.13-3.15 give the results for M2 as percentage of GDP, Figures 3.16-3.18 report the outcomes for claims on central government as percentage of GDP, while Figures 3.19-3.21 provide our findings for total reserves in months of imports.

Figures 3.10-3.12 show clear differences between two types of crisis in hard pegs and other pegs; however, this difference does not show up in intermediate regimes. In hard pegs, sudden stops followed by a currency crash have a high level of trade openness, but trade openness declines before the crisis. In the category of other pegs, a sudden stop with a currency crash coincides with low trade openness.

The results for M2 as percentage of GDP are shown in Figures 3.13-3.15. There is no markedly dissimilar pattern for hard pegs and other pegs with respect to the level of financial development. However, in intermediate regimes countries facing a sudden stop with a currency crash have shallow financial markets.

Figures 3.15-3.18 show the results for claims on government as percentage of GDP. In hard pegs, a deterioration of the government's fiscal position is observed three years ahead of a crisis. However, in the categories of other pegs and intermediate regime, the government's fiscal position is not different in both types of crisis.

The results for reserves are provided in Figures 3.19-3.21. In hard pegs, reserves are much lower compared to tranquil times in both types of crisis, although this effect seems stronger in sudden stops with a currency crash compared to sudden stops without a currency crash. This pattern is not visible in other pegs and intermediate regimes. It is clear that lack of sufficient reserves marks currency crashes in hard pegs unlike the categories of other pegs and intermediate regimes.

These results are in line with our expectations. Under a hard peg, trade openness seems poisonous especially when reserves are limited and fiscal policy is expansionary. Under a more flexible exchange rate regime, shallow financial markets create vulnerabilities. The channels through which fiscal imbalances affect the exchange rate have been explained in the first generation currency crisis models which assumes a fixed exchange rate regime (Krugman, 1979). Countries are prone to currency crisis when government expenditures grow faster than the government revenue during reserve losses and real exchange rate appreciations, the latter is more often when the trade openness is less. Economies with deeper financial markets typically have a smoother broad money multiplier and can manage to maintain a consistently higher backing of domestic bank liabilities or paper money. These economies were the ones that managed to overcome the sudden stop shock while keeping their currency stable. This evidence verifies Whale (1937) and Ford (1962) of the importance of the domestic financial imperfections in propagating capital account shocks and accounting for cross-country differences in macroeconomic adjustment.

Figure 3.10 Trade (% of GDP) Hard pegs

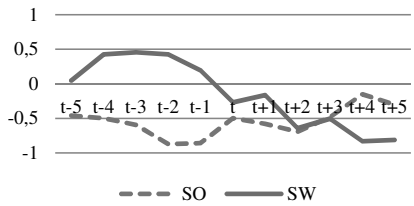


Figure 3.11 Trade (% of GDP) Other pegs

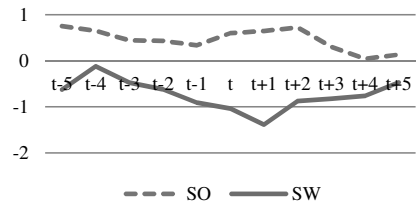


Figure 3.12 Trade (% of GDP) Intermediate

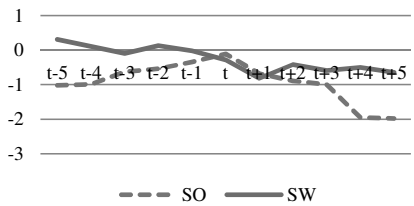


Figure 3.13 Money and quasi money (M2) as % of GDP Hard pegs

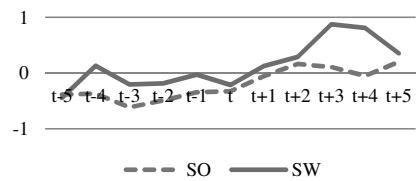


Figure 3.14 Money and quasi money (M2) as % of GDP Other pegs

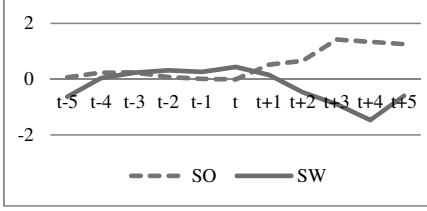


Figure 3.15 Money and quasi money (M2) as % of GDP Intermediate

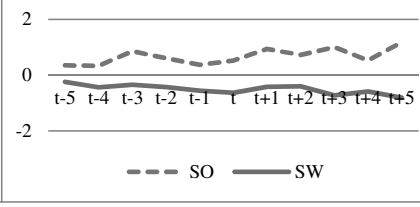


Figure 3.16 Claims on central government (% GDP) Hard pegs

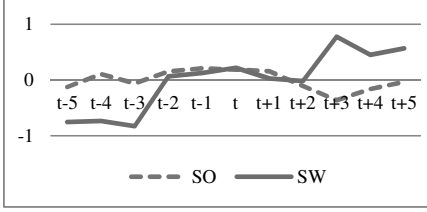


Figure 3.17 Claims on central government (% GDP) Other pegs

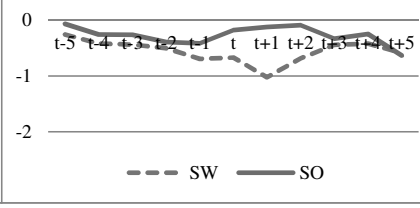


Figure 3.18 Claims on central government (% GDP) Intermediate

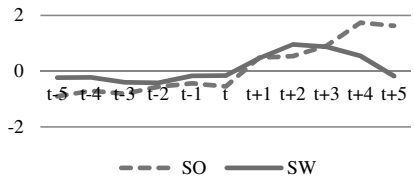


Figure 3.19 Total reserves in months of imports Hard pegs

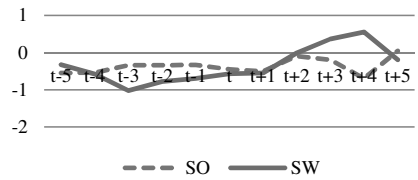


Figure 3.20 Total reserves in months of imports Other pegs

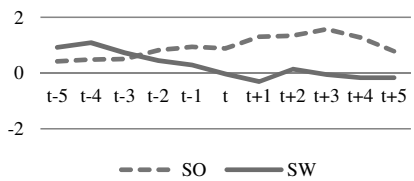
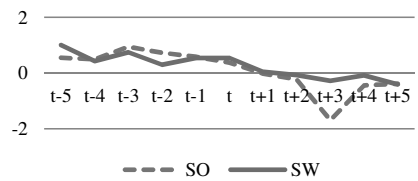


Figure 3.21 Total reserves in months of imports Intermediate



The event study approach as presented in this section has two limitations. First, this approach is based on bivariate models. Second, this approach does not allow us to assess statistical significance. We therefore also estimate panel discrete-choice models.

3.5 Logit model estimates

In this section, we estimate panel logit models with country fixed effects. We assume that there exists an unobservable variable y_{it}^* that indicates whether economy *i* has a sudden stop with a currency crash or not between periods $t + 1$ and $t + k$. We vary k between one and three years (Bussière and Fratzscher, 2006; Gourinchas and Obstfeld, 2012). This unobservable indicator y_{it}^* is a linear function of a vector of n exogenous determinants, x_{it}, a constant a and a random error term ε_{it}. x_{it} stands for the factors which might be related to whether a sudden stop with a currency crash or a sudden stop without a currency crash takes place. We assume that a country has a sudden stop with a currency crash if the unobservable indicator is greater than zero.

$$d_{it} = \begin{cases} 1 \; if \; y_{it} > 0 \\ 0 \; if \; y_{it} \leq 0 \end{cases}$$

Thus, the probability of observing a sudden stop with a currency crash between periods $t + 1$ and $t + k$, i.e. the probability that d_{it}=1, is

$$\text{Prob}(d_{it} = 1) = \text{Prob}(y_{it}^* > 0) = \text{Prob}(a + b'x_{it} + \varepsilon_{it} > 0) = \text{Prob}(\varepsilon_{it} > -a - b'x_{it}).$$

Using the logistic distribution function, the probability of a sudden stop with a currency crash is as follows:

$$\text{Prob}(d_{it} = 1) = \text{Prob}(\varepsilon_{it} < a + b'x_{it}) = \frac{\exp(\alpha + \beta' x_{it})}{1 + \exp(\alpha + \beta' x_{it})}$$

where α is a constant, β is a vector of parameters. The dependent variable is a dummy which is one if a sudden stop is followed by a currency crash and zero if a sudden stop is not followed by a currency crash.

The high correlation between the potential determinants as shown in Table 3.4 restricts us from using them in a logit model simultaneously. In order to deal with this problem, we employ factor analysis. Factor analysis provides a convenient method of rank reduction. The Kaiser-Meyer-Olkin (KMO = 0.56) index and Bartlett's test (p = 0.000) suggest that factor analysis is applicable in our sample. Therefore, we use factors derived from the factor analysis as explanatory variables in our logit models. The details of the factor analysis are presented in Appendix 3.E.

Table 3.4 Correlation matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Trade (% of GDP) (1)	1								
Exports of goods and services (% of GDP) (2)	0.9105	1							
Current account balance (% of GDP) (3)	0.2178	0.4275	1						
Financial openness (4)	0.4423	0.4178	0.1524	1					
Money and quasi money (M2) (% of GDP) (5)	0.4118	0.3022	0.0894	0.5045	1				
Domestic credit provided by banking sector (% of GDP) (6)	0.2336	0.1301	-0.1374	0.2123	0.5841	1			
Inflation, consumer prices (annual %) (7)	-0.0719	-0.1239	-0.3172	-0.1972	-0.2776	-0.0907	1		
Claims on central government (% of GDP) (8)	0.0072	0.0051	0.0959	-0.1228	-0.0234	0.3145	-0.0231	1	
Total reserves in months of imports (9)	0.0363	0.0615	0.1765	0.1248	0.036	-0.1365	-0.0474	-0.3866	1

Note: the number of observations is not the same for each variable.

There is no single "best" criterion for dropping the least important factors (Jacobs et al., 2008). Previous studies depend on one or more of the following criteria to determine how many factors to retain. The Kaiser criterion drops all factors with eigenvalues below one. The Cattell scree test suggests selecting the number of factors that corresponds to the curve (the eigenvalues are plotted on the vertical axis and the factors on the horizontal axis) where the smooth decrease of eigenvalues appears to level off to the right of the plot. The parallel analysis is based on the Monte Carlo simulation. Essentially, the procedure first creates a random dataset with the same numbers of observations and variables as the original data. Secondly, a correlation matrix is computed from the randomly generated dataset and then the eigenvalues of the correlation matrix are computed. If the eigenvalues from the random data are larger than the eigenvalues from the factor analysis, we know that the components or factors are mostly random noise. In general, the scree test provides a lower bound on the number of factors, while the Kaiser Criterion offers a higher bound (Jacobs et al., 2008). We use parallel analysis since Hayton et al. (2004) present evidence that parallel analysis is one of the most accurate factor retention methods.. This indicates that there are at least four factors (See Appendix 3.F). Table 3.D.1 provides eigenvalues and shows the cumulative variance explained. Table 3.D.2 shows the factor loadings and unique variance of the variables used. Table 3.D.3 lists rotated factor loadings and unique variances.[23] Table 3.D.3 shows that the first factor captures *trade openness*, as trade and exports have high loadings. The second factor captures *financial development*, as the following variables have high loadings: financial openness, money and quasi money (M2) as percentage of GDP and domestic credit provided by the banking sector (as percentage of GDP). The third factor takes up the *current account*, while the fourth factor is *public finance*, with high loadings of claims on central government and total reserves in months of imports. We arrive at four factors according to the rotated factor loadings in Table 3.D.3 that are used as explanatory variables in the logit model to derive our base model. Table 3.D.4 shows the correlation between each factor.

[23] The varimax rotation keeps the axes orthogonal to one another and moves them into a position where each variable loads onto one factor as highly as possible while loading onto the second factor as low as possible.

We test the null hypothesis that all coefficients (except for the constant) are equal to zero using likelihood ratio statistics. Following Demirgüç-Kunt and Detragiache (2000) and Gourinchas and Obstfeld (2012), we drop crisis observations and the post-crisis observations for five years afterward, so as to avoid the post-crisis bias discussed in Bussière and Fratzscher (2006). The results of the panel logit model are shown in Table 3.5. The likelihood ratio suggests that our models as a whole are statistically significant. The entries in the table present the marginal effects on the probability of a sudden stop followed by a currency crash (expressed in percentage points), evaluated at the mean of the data. The associated z-statistics, which test the null hypothesis of no effect for each factor are shown in parentheses.

Table 3.5 Logit model: marginal effects

	(1)	(2)	(3)	(4)	(5)	(6)
	k=1		k=2		k=3	
	SO	SW	SO	SW	SO	SW
Openness	0.170***	-0.229***	0.153***	-0.232***	0.139***	-0.212***
	(3.52)	(-3.71)	(4.25)	(-4.95)	(4.46)	(-5.20)
Financial development	0.195***	0.006	0.205***	-0.014	0.188***	-0.042
	(3.47)	(0.09)	(4.87)	(-0.28)	(5.23)	(-0.98)
Current account	0.362***	-0.072	0.306***	-0.108	0.267***	-0.103*
	(5.29)	(-1.03)	(5.85)	(-1.88)	(5.85)	(-1.99)
Public finance	0.012	0.070	-0.006	0.064	-0.033	0.068
	(0.18)	(1.02)	(-0.11)	(1.18)	(-0.68)	(1.41)
N	500	392	567	427	624	455
Log likelihood	-97.968***	-72.551***	-171.834***	-119.402***	-229.201***	-153.187***

Note: The dependent variable is a sudden stop with/without a currency crash. SO = 1 when a sudden stop is not followed by a currency crash between periods t + 1 and t + k, while SW = 1 when a sudden stop is followed by a currency crash between periods t + 1 and t + k. z statistics for each variable are in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Marginal effect is for discrete change of dummy variable from 0 to 1, the coefficients refer to marginal effects at mean.

The panel logit estimates yield statistically and economically significant effects of our key variables. The results are consistent with the outcomes of our event study approach and indicate that several of the indicators behave differently before the two types of crisis, notably trade openness, financial development and current account imbalances. An increase in trade openness significantly increases the chances of a sudden stop without a currency crash, but it decreases the chance of a sudden stop

with a currency crash. The marginal effect is sizable: If openness increases by 1%, the probability of a sudden stop without a currency crash increases by 0.14-0.17 percent. If openness increases by 1%, the probability of a sudden stop with a currency crash decreases by 0.21-0.23 percent. The coefficients for current account imbalances are smaller. A 1 percent improvement of the current account balance decreases the probability of a sudden stop followed by a currency crash by 0.1 percent. The sign of financial development is in line with our expectations. A well-developed financial sector increases the probability of a sudden stop without a currency crash. It appears that our indicator of public finances is not significant.

To wrap up, in the logit model, trade openness, financial development and current account imbalances are significantly related to whether or not sudden stops are followed by currency crashes.

As shown in Section 3.4, the exchange rate regime may affect the factors which influence whether or not a sudden stop is followed by a currency crash. We therefore examine developments under different exchange rate regimes in logit models as shown in Table 3.6.

Table 3.6 Logit model: marginal effects in various exchange rate regimes

Exchange rate regime		k=1		k=2		k=3	
	crisis type	SO	SW	SO	SW	SO	SW
Hard pegs	Trade openness	-0.0001	-0.438	0.023	-0.365***	-0.024*	-0.278***
		(-0.00)	(-1.13)	(0.28)	(-3.37)	(-0.37)	(-2.35)
	Financial development	0.190	0.249	0.201	0.206	0.159	0.058
		(1.39)	(1.05)	(1.98)	(1.45)	(1.90)	(0.47)
	Current account	0.096	-0.380	0.054	-0.410***	-0.022*	-0.261**
		(0.57)	(-1.17)	(0.42)	(-3.33)	(-0.22)	(-2.02)
	Public finance	0.045	-0.334	0.149	-0.246	0.033	-0.323**
		(0.24)	(-1.12)	(1.24)	(-1.61)	(0.32)	(-1.88)
	Number of Observations	74	45	87	53	100	58
	Log likelihood	-16.283	-4.510***	-28.544	-14.714***	-39.547	-21.213**
Other pegs	Trade openness	0.333**	-0.324	0.516***	-0.239	0.454***	-0.117
		(2.46)	(-1.17)	(4.98)	(-1.19)	(5.23)	(-0.68)
	Financial development	0.210***	-0.048	0.197**	-0.056	0.253***	-0.046
		(2.77)	(-0.38)	(1.81)	(-0.53)	(2.72)	(-0.46)
	Current account	0.411**	0.091	0.459***	0.112	0.419***	0.076
		(2.58)	(0.54)	(4.35)	(0.72)	(4.21)	(0.52)
	Public finance	0.042	-0.165	0.105	-0.305	0.068	-0.267
		(0.49)	(-0.62)	(0.97)	(-1.29)	(0.69)	(-1.32)
	Number of Observations	126	49	157	57	207	63
	Log likelihood	-6.738***	-12.742	-28.775***	-20.847	-49.510***	-26.580
Intermediate	Trade openness	-0.041		-0.008		0.053	
		(-0.36)		(-0.09)		(0.72)	
	Financial development	0.194		0.270**		0.315***	
		(1.36)		(2.30)		(2.94)	
	Current account	0.471***		0.515***			
		(2.59)		(2.92)		(2.76)	
	Public finance	0.026		0.541		0.056	
		(0.15)		(0.40)		(0.46)	
	Number of Observations	63		94		103	
	Log likelihood	-17.026***		-25.794***		-25.794***	

Note: The dependent variable is a sudden stop with/without a currency crash. SO = 1 when a sudden stop is not followed by a currency crash between periods t + 1 and t + k, while SW = 1 when a sudden stop is followed by a currency crash between periods t + 1 and t + k. z statistics for each variable are in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. Marginal effect is for discrete change of dummy variable from 0 to 1, the coefficients refer to marginal effects at mean.

The results for the hard peg regime show that low trade openness, current account and budget deficits increase the probability of a sudden stop with a currency crash.

The results for the other pegs category indicate that the probability of having a sudden stop with a currency crash increases when trade openness is low, the current account is in deficit and the financial sector is shallow. In intermediate regimes, financial development and current account imbalances appear as significant factors associated with sudden stops followed by currency crashes.

Some of the multivariate models for a specific exchange rate regime are not significant which is probably due to the small sample size. Still, most results are in line with the findings of the event study approach.

3.6 Conclusions

We investigate what determines whether or not a sudden stop, i.e. a decrease in international capital inflows, is followed by a currency crash, i.e. a large drop in the nominal exchange rate accompanied by an increasing rate of depreciation. Sometimes sudden stops occur simultaneously with currency crashes, but on other occasions the exchange rate does not respond to a sudden stop at all. We employ a sample of 85 countries in the period 1980-2012, yielding a total of 158 sudden stops. In our sample, about one third of the sudden stops were followed by a currency crash and most of these took place in less advanced economies. The frequency of sudden stops with currency crashes is smaller in the 21st century than in the 1980s and 1990s.

Our results are based on the event study approach and logit estimates. The results of both approaches are fairly similar. We observe that economies with low trade openness, a shallow financial sector, and current account imbalances are most prone to sudden stops with currency crashes. As such, we complement the existing research of Catão (2007), Efremidze and Tomohara (2011) and Efremidze et al. (2011). We also find that the exchange rate regime in place affects which factors determine whether or not a sudden stop is followed by a currency crash. Our results suggest that in order to reduce the likelihood that a sudden stop is followed by a currency crash trade openness should be higher and fiscal policy should be prudent under hard pegs; trade openness should be high and the financial sector should be well-developed under other pegs, while financial development is important under intermediate exchange rate regimes. Our results confirm the view of Lane and Milesi-Ferretti (2012) that the impact of a sudden stop differs across exchange rate regimes.

Appendix

3.A Sudden stops with/without currency crashes (1980-2008)

Countries	Periods		
Albania	1994 Jan - 1994 Jun	1999 May	N
	1995 Jan - 1995 May		
	1996 Jul - 1997 Aug		
	1998 Oct - 2008 Dec		
Argentina	1980 Jan - 2008Dec	1980 Mar	Y
Aruba	1986 Jan - 1988 Dec	2003 Apr	N
	1995 Jan – 2008 Dec		
Austria	1980 Jan - 2008 Dec	1988 Dec	N
		1995 Oct	N
		1999 Jan	Not available
		2002 Oct	Not available
Barbados	1980 Jan - 2008 Dec	1983 Jul	Y
		1999 Jan	N
Belgium	1993 Jan - 2008Dec	1998 Dec	Not available
Bolivia	1980 Jan - 1992 Jun	1980 Jan	Y
	1994 Oct - 2008 Dec		
Botswana	1980 Jan - 1998 May	1986 Apr	N
	1999 Jan - 1999 Jul	1991 Mar	Y
Brazil	1980 Jan - 2008 Dec	1980 Jan	Y
Bulgaria	1995 Jan – 2008 Dec	1995 Jul	Y
Burundi	1980 Jan - 2008 Dec	1980 Jul	N
		1986 Feb	Y
Canada	1980 Jan - 2008 Dec	1997 Nov	N
		2000 Dec	N
		2004 Jun	N
		2008 Jul	N
China, P.R.: Hong Kong	1990 Dec - 1991 Jan	1993 Jan	N
	1991 Dec - 1992 Jan	1996 Jan	N
	1992 Dec - 1993 Jan		
	1993 Dec - 1994 Jan		
	1994 Mar - 1994 Apr		
	1994 Jun - 1994 Jul		
	1994 Sep - 1994 Oct		
	1994 Dec - 1995 Jan		
	1995 Mar - 1995 Apr		
	1995 Jun - 1995 Jul		
	1995 Sep - 1995 Oct		
	1995 Dec - 1996 Jan		
	1996 Mar - 1996 Apr		
	1996 Jun - 1996 Jul		
	1996 Sep - 1996 Oct		
	1996 Dec - 2008 Dec		
Colombia	1980 Jan - 2008 Dec	1984 Jan	Y
Congo, DR	1980 Jan - 1988 Dec	1980 Jan	Y
	1989 Jul - 1991 Apr		
	1991 Jun - 1993 Aug		
	1993 Nov - 1996 Aug		
Cote d'Ivoire	1980 Jan - 2008 Dec	1985 Oct	N
Croatia	1992 Dec - 1994 Jun	1993 Apr	Not available

	1994 Aug - 2008 Dec		
Cyprus	1980 Jan - 2008Dec	2008 Jan	Not available
Czech Republic	1993 Jan - 2008 Dec	1997 May	Y
		2005 Jan	N
		2008 May	N
Denmark	1980 Jan - 2008 Dec	1993 Jan	N
		1998 Aug	N
		2005 Oct	N
		2008 Oct	N
Dominica	1993 Jan - 2008 Dec	2003 Aug	N
Dominican Republic	1980 Jan - 2008 Dec	1981 May	N
		1985 May	Y
Ecuador	1980 Jan - 2008 Dec	1980 Jan	Y
		1983 Mar	Y
El Salvador	1991 Jan – 2008 Dec	1998 Aug	N
		2002 May	N
Estonia	1994 Jan – 2008 Dec	2007 Aug	N
Fiji	1980 Jan - 1997 Jun	1987 Jun	Y
	1997 Sep - 1998 Mar	1991 Apr	N
	2002 Jan – 2008 Dec		
Finland	1980 Jan - 2008 Dec	1991 May	Y
		1995 Dec	N
		1999 Jan	Not available
		2006 Feb	Not available
France	1980 Jan - 2008 Dec	1981 Jun	Y
		1992 Nov	N
		1996 Aug	N
Gambia	1980 Jan - 1992 Feb	1981 Jul	Y
	1992 Oct - 1996 Feb	1992 Feb	N
	1997 Jan - 1999 Dec		
	2002 Jan - 2005 May		
Georgia	1995 Oct - 2008 Dec	1999 Feb	Y
Greece	1980 Jan - 1994 Aug	1996 May	N
	1994 Nov - 2008 Dec	2000 Dec	Not available
Guatemala	1980 Jan - 1989 Jul	1980 Feb	N
	1990 Jan - 2008 Dec	1984 Feb	Y
Haiti	1980 Jan - 1981 Sep	1988 Oct	Y
	1985 Oct - 1991 Dec		
	1994 Mar - 2008 Dec		
Honduras	1980 Jan - 1983 Nov	1980 Jan	N
	1984 Nov - 1987 Nov	1983 Mar	Y
	1996 Jan - 2008 Dec	1986 Mar	N
Hungary	1983 Dec - 1984 Jan	1984 Jan	N
	1984 Dec - 1985 Jan	1987 Jan	N
	1985 Dec - 1986 Jan		
	1986 Dec - 1987 Jan		
	1987 Mar - 1987 Apr		
	1987 Jun - 1987 Jul		
	1987 Sep - 1987 Oct		
	1987 Dec - 1987 Jan		
	1988 Mar - 1988 Apr		
	1988 Jun - 1988 Jul		
	1988 Sep - 1988 Oct		
	1988 Dec – 1989 Jan		
	1989 Mar - 1989 Apr		
	1989 Jun - 2008 Dec		
India	1980 Jan - 2008 Dec	2008 Oct	N
Indonesia	1980 Jan - 2008 Dec	1980 Feb	Y

		1983 Oct	Y
		1998 Feb	Y
Italy	1980 Jan - 1985 Jan	1985 Jan	N
	1999 Jan - 2008 Dec		
Jamaica	1980 Jan - 2008 Dec	1980 Feb	N
Japan	1980 Jan - 2008 Dec	1998 Apr	N
		2004 Apr	N
Jordan	1980 Jan – 2008 Dec	1988 Jan	Y
		1991 Aug	N
		2008 Mar	N
Kazakhstan	1995 Sep - 2008 Dec	2006 Jun	N
Kenya	1980 Jan- 2008 Dec	1980 May	Y
		1993 Jul	Y
Korea	1980 Jan - 2008 Dec	1988 Dec	N
		1997 Nov	Y
		2008 Jul	Y
Kuwait	1980 Jan - 1984 Mar	1980 Jan	N
	1993 Jan - 2004 Dec	2007 Dec	N
	2005 Mar		
	2005 Jun		
	2007 Dec		
	2008 Mar		
	2008 Jun		
	2008 Sep		
	2008 Dec		
Kyrgyz Republic	1997 Jan	1997 Jan	Y
	1997 Mar - 1997 Apr		
	1997 Jun - 1997 Jul		
	2002 Jan - 2008 Dec		
Latvia	1993 Jul - 2008 Dec	2008 Nov	N
Lithuania	1994 Jan - 1994 May	2008 Nov	N
	1994 Jul - 2008 Dec		
Macedonia, FYR	1993 Dec - 2008 Dec	2006 Jan	N
Malawi	1980 Jan -1997 Jan	1980 Oct	Y
	1998 Apr - 2006 Mar		
Malaysia	1980 Jan - 2008 Dec	1994 Dec	Y
		2005 Oct	N
		2008 Oct	N
Malta	1980 Jan - 2003 Oct	2003 Oct	N
	2004 Feb - 2008 Dec	2008 Jan	Not available
Mexico	1980 Jan - 2011 Dec	1981 Sep	Y
Mongolia	1992 Dec - 1994 Dec	1992 Dec	Y
	1996 Jan - 1997 May		
	1999 Jul - 1999 Dec		
	2002 Jun - 2008 Dec		
Morocco	1980 Jan - 2008 Dec	2008 Oct	N
Myanmar	1980 Jan - 2008 Dec	1980 Sep	N
		1984 Jul	N
Nepal	1980 Jan - 2005 Jul	1981 Jun	N
		1984 Dec	Y
		1989 Aug	Y
		2002 Feb	N
Netherlands	1980 Jan - 2008 Dec	1999 Jan	Not available
		2006 Feb	Not available
Netherlands Antilles	1980 Jan - 1980 Dec	1980 Apr	N
	1981 Jul - 1981 Dec	1983 Apr	Y
	1983 Jan - 1984 Dec		
	1986 Jan - 1988 Dec		

	1989 Jun - 1994 Dec		
Nigeria	1980 Jan - 1994 Dec	1980 Jan	N
	1995 Feb - 1995 Apr		
	1995 Jun - 1995 Nov		
	1996 Jan - 1999 Jun		
	2001 Oct - 2008 Dec		
Norway	1980 Jan - 2008 Dec	1996 Dec	N
		2000 Jun	N
		2005 Mar	N
		2008 Mar	N
Pakistan	1980 Jan - 2008 Dec	1995 Jul	N
		2001 Jul	N
Panama	1980 Jan - 2008 Dec	1997 Jun	N
Paraguay	1980 Jan - 1994 Dec	1982 Aug	Y
	1998 Jan - 1998 Apr		
	2007 Jan - 2008 Dec		
Peru	1980 Jan - 2008 Dec	1980 Jan	Y
Philippines	1980 Jan - 2008 Dec	1981 Jan	Y
		1998 Aug	Y
Portugal	1980 Jan - 2008 Dec	1992 Sep	Y
		1999 Jan	Not available
Russian Federation	1993 Dec - 1994 Jan	1994 Jan	Not available
	1994 Mar - 1994 Apr		
	1994 Jun - 1994 Jul		
	1994 Sep - 1994 Oct		
	1994 Dec - 2008 Dec		
Samoa	1983 Jan - 2008 Dec	1988 Jun	N
		1992 Nov	N
		1998 Jan	N
Serbia	2004 Jan - 2008 Dec	2008 Oct	Y
Singapore	1980 Jan - 2008 Dec	1997 Dec	N
		2001 Mar	N
		2004 Apr	N
		2008 Jul	N
Slovakia	1993 Jan - 2008 Dec	2004 Jun	N
		2008 Oct	Not available
Slovenia	1991 Dec - 2008 Dec	2007 Jan	Not available
Solomon Islands	1980 Jan - 1984 Sep	1980 Oct	Y
	1985 Jan - 1987 Mar		
	1990 Jun - 1991 Feb		
South Africa	1980 Jan - 2008 Dec	1980 Jan	Y
		1983 Mar	Y
Spain	1980 Jan - 2008 Dec	1992 Sep	Y
		1998 Dec	Not available
Sri Lanka	1980 Jan - 2008 Dec	2000 Mar	N
St. Lucia	1994 Jan - 2008 Dec	1995 Jun	N
		2004 Oct	N
Sweden	1980 Jan - 2008 Dec	1992 Apr	Y
		1996 Nov	N
		2008 Oct	N
Switzerland	1980 Jan - 2008 Dec	1980 Jan	N
		1993 Jan	N
		1996 Jan	N
		2000 Jan	N
		2005 Apr	N
Thailand	1980 Jan - 2008 Dec	1997 May	Y
		2008 May	N
Togo	1980 Jan - 1980 Dec	1980 Aug	Y

	1982 Jan - 1983 Sep	2004 Jul	N
	1984 Jan - 1984 Sep		
	1995 Aug - 1997 Dec		
	1999 Jan - 1999 Jul		
	2000 Jan - 2006 Nov		
Trinidad and Tobago	1980 Jan - 2008 Dec	1980 Aug	N
		2006 Sep	N
Uruguay	1980 Jan - 2008 Dec	1982 Jan	Y
Venezuela	1980 Jan - 1998 Feb	1980 Jan	N
	1998 Apr	1983 Jan	Y
	1998 Jul - 1998 Aug		
	1998 Dec - 2008 Aug		

Note: Sources of data: IFS. The second column shows the period for which we have data on capital flows. The third column shows the sudden stops identified. The fourth column shows whether sudden stops are followed by currency crashes in 36 months using the definition of currency crashes from Frankel and Rose (1996). “N” denotes sudden stop without currency crash. “Y” denotes sudden stop with currency crash. In our sample, advanced economies include Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Finland, France, Greece, Hong Kong, Italy, Japan, Malta, Netherlands, Norway, Portugal, Singapore, Slovakia, Slovenia, South Korea, Spain, Sweden, and Switzerland.

3.B Reinhart and Rogoff's (2004) classification of exchange regimes

1	No separate legal tender
1	Pre announced peg or currency board arrangement
1	Pre announced horizontal band that is narrower than or equal to ±2%
1	De facto peg
2	Pre announced crawling peg
2	Pre announced crawling band that is narrower than or equal to ±2%
2	De facto crawling peg
2	De facto crawling band that is narrower than or equal to ±2%
3	Pre announced crawling band that is wider than or equal to ±2%
3	De facto crawling band that is narrower than or equal to ±5%
3	Moving band that is narrower than or equal to ±2% (i.e., allows for both appreciation and depreciation over time)
3	Managed floating
4	Freely floating
5	Freely falling
6	Dual market in which parallel market data is missing

Source: Reinhart and Rogoff (2004).

3.C Definitions and sources of variables

Variables	Data Source	Reference
Inflation, consumer prices (annual %)	WDI	Calvo, 1998
Claims on central government (% GDP)	WDI	Flood and Jeanne, 2005; Catão, 2007
Money and quasi money (M2) as % of GDP	WDI	Calderón and Liu, 2003
Trade (% of GDP)	WDI	Calvo, 1998; Cowan et al., 2008
Financial openness	Lane and Milesi-Ferretti (2007)	Calvo, 1998; Cowan et al., 2008
Exports of goods and services (% of GDP)	WDI	Calvo, 1998; Cowan et al., 2008
Current account balance (% of GDP)	WDI	Calvo, 1998 & 2004
Total reserves in months of imports	WDI	Catão, 2007
Domestic credit provided by banking sector (% of GDP)	WDI	Catão 2007

Note: Financial openness comes from Lane and Milesi-Ferretti (2007) who have updated their data until 2010.

3.D The results of various exchange rate regimes

Figure 3.D.1 Exports of goods and services (% of GDP) Hard pegs

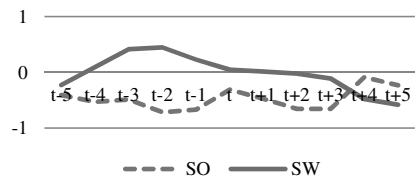


Figure 3.D.2 Exports of goods and services (% of GDP) Other pegs

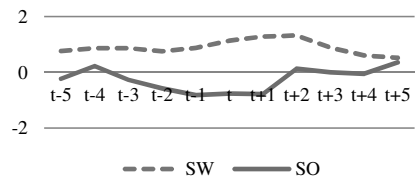


Figure 3.D.3 Exports of goods and services (% of GDP) Intermediate

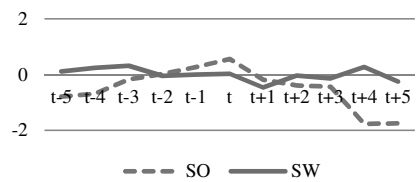


Figure 3.D.4 Current account balance (% of GDP) Hard pegs

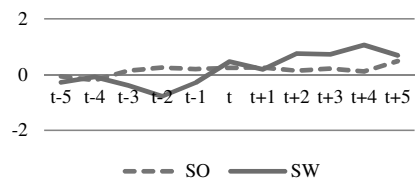


Figure 3.D.5 Current account balance (% of GDP) Other pegs

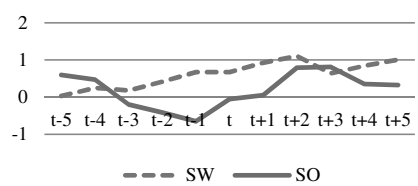


Figure 3.D.6 Current account balance (% of GDP) Intermediate

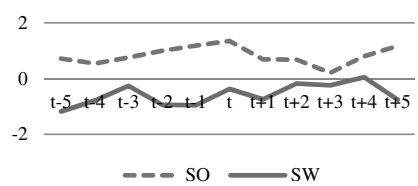


Figure 3.D.7 Financial openness Hard pegs

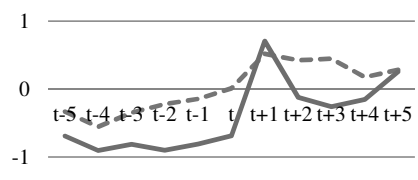


Figure 3.D.8 Financial openness Other pegs

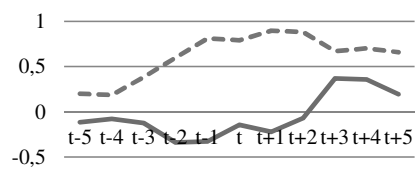


Figure 3.D.9 Financial openness Intermediate

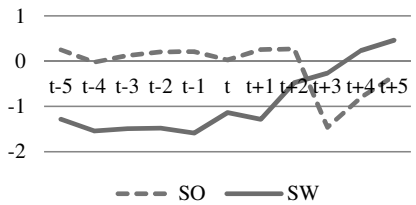


Figure 3.D.10 Domestic credit provided by banking sector (% of GDP) Hard pegs

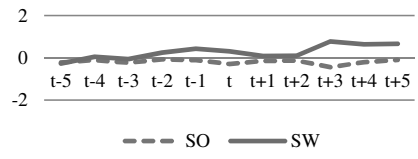


Figure 3.D.11 Domestic credit provided by banking sector (% of GDP) Other pegs

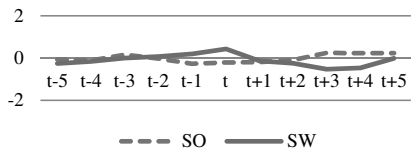


Figure 3.D.12 Domestic credit provided by banking sector (% of GDP) Intermediate

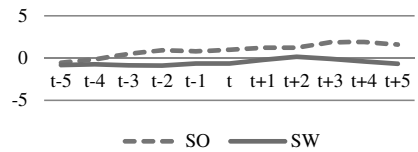


Figure 3.D.13 Inflation, consumer prices (annual %) Hard pegs

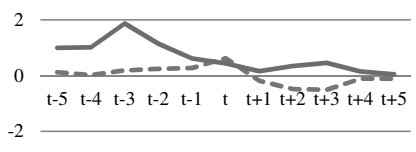


Figure 3.D.14 Inflation, consumer prices (annual %) Other pegs

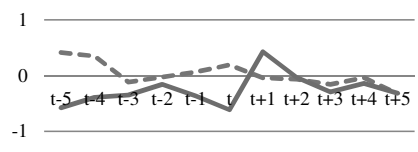
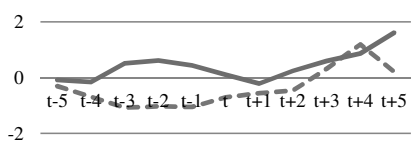


Figure 3.D.15 Inflation, consumer prices (annual %) Intermediate



3.E Factor analysis

Table 3.E.1 Eigenvalues and cumulative variance explained

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	2.47938	1.3294	0.6078	0.6078
Factor2	1.14998	0.40778	0.2819	0.8897
Factor3	0.74219	0.45182	0.182	1.0717
Factor4	0.29037	0.31391	0.0712	1.1429
Factor5	-0.02355	0.03327	-0.0058	1.1371
Factor6	-0.05682	0.03836	-0.0139	1.1232
Factor7	-0.09518	0.08097	-0.0233	1.0998
Factor8	-0.17615	0.05498	-0.0432	1.0567
Factor9	-0.23113		-0.0567	1

Note: LR test: independent vs. saturated model: chi2 (36) = 6933.23, Prob>chi2 = 0.0000.

Table 3.E.2 Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Trade (% of GDP)	0.8064	-0.2904	-0.3562	-0.1255	0.1228
Total reserves in months of imports	0.138	-0.1887	0.5121	-0.0499	0.6806
Money and quasi money (M2) as % of GDP	0.6388	0.395	0.257	-0.1627	0.3434
Inflation, consumer prices (annual %)	-0.2289	-0.0989	-0.2002	0.0565	0.8946
Exports of goods and services (% of GDP)	0.8314	-0.4026	-0.186	0.1055	0.101
Domestic credit provided by banking sector (% of GDP)	0.4486	0.6727	-0.0392	0.048	0.3424
Current account balance (% of GDP)	0.2675	-0.2537	0.3541	0.3686	0.6028
Claims on central government (% of GDP)	0.0491	0.4172	-0.2475	0.3052	0.6691
Financial openness	0.619	0.106	0.1555	0.0034	0.5814

Table 3.E.3 Rotated factor loadings (pattern matrix) and unique variance

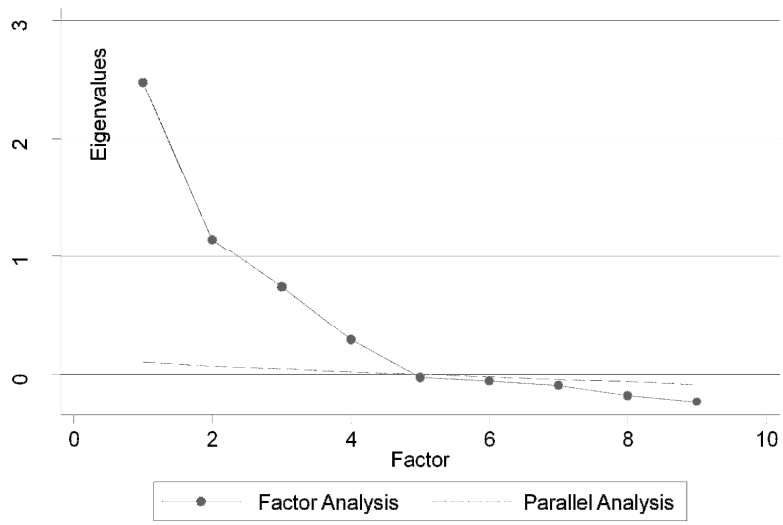
Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Trade (% of GDP)	0.9205	0.139	-0.1009	-0.0206	0.1228
Total reserves in months of imports	0.0075	0.0803	0.3655	-0.4235	0.6806
Money and quasi money (M2) as % of GDP	0.2487	0.7526	0.0736	-0.1514	0.3434
Inflation, consumer prices (annual %)	-0.068	-0.2667	-0.1075	0.1346	0.8946
Exports of goods and services (% of GDP)	0.9226	0.0821	0.2026	-0.0062	0.101
Domestic credit provided by banking sector (%)	0.0748	0.7505	-0.0705	0.2895	0.3424
Current account balance (% of GDP)	0.191	0.0002	0.5969	-0.0665	0.6028
Claims on central government (% of GDP	-0.0628	0.2387	-0.0359	0.5183	0.6691
Financial openness	0.3967	0.4672	0.1904	-0.0822	0.5814

Table 3.E.4 Factor rotation matrix

	Factor1	Factor2	Factor3	Factor4
Factor1	0.8115	0.5529	0.1828	-0.0489
Factor2	-0.45	0.773	-0.2393	0.3777
Factor3	-0.3721	0.2793	0.6447	-0.6065
Factor4	-0.023	-0.137	0.7026	0.6979

Note: correlation matrix between each factor.

3.F Parallel Analysis



Note: We use factors before rotation to arrive at this figure. The figure with factors after rotation also shows four factors.

Chapter 4

Leading Indicators of Currency Crises: Are They the Same in Different Exchange Rate Regimes?

4.1 Introduction

The recent financial crisis renewed interest in studying leading indicators of such crises. At its London summit of April 2009, the G20 called for the newly established Financial Stability Board and the IMF "to provide early warning of macroeconomic and financial risks and the actions needed to address them"[24]. Reinhart and Rogoff (2009) distinguish five types of financial crises: external default, domestic default, banking crises, currency crises, and inflation outbursts. We focus on currency crises because a large number of studies concentrate on currency crises and Corsetti et al. (1999) and Corbett and Vines (1999) use currency crisis and financial crisis interchangeably.

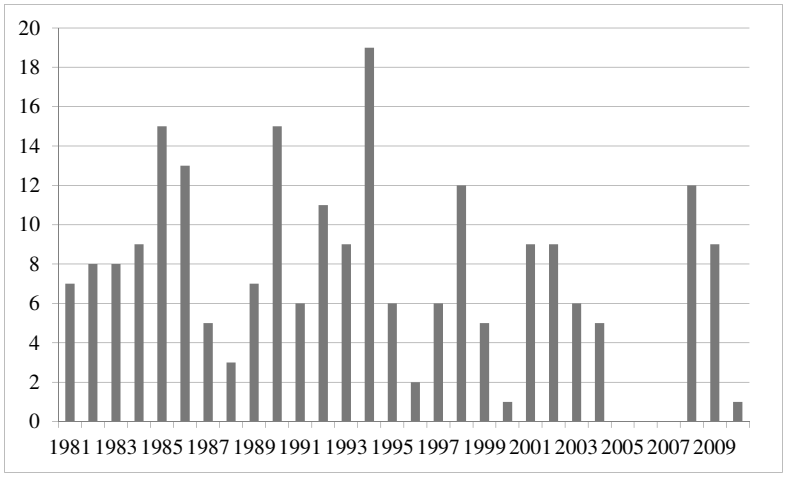
After 2008, the number of currency crises increased (see Figure 4.1). Frankel and Saravelos (2012) find that countries with a floating exchange rate regime were quite vulnerable in the 2008–2009 global financial crises. In the past, however, almost all currency crises occurred in fixed and semi-fixed exchange rate regimes. The most prominent examples include the Latin American currency crises in the 1980s, the ERM crisis in 1992, and the Asian crisis in 1997. Indeed, Falcetti and Tudela (2006) find that countries with a fixed exchange rate regime are more vulnerable than countries with a flexible exchange rate regime. Still,

[24] Point 15, p3 of Final CommuniquéG-20 Summit April 2, 2009, available at http://www.g20.org/Documents/final-communique.pdf. See also Declaration on Strengthening the Financial System (http://www.g20.org/Documents/Fin_Deps_Fin_Reg_Annex_020409_-_1615_final.pdf)

during the recent financial crisis all types of exchange rate regimes seemed to be vulnerable, as pointed out by Fratzscher (2009). We therefore examine whether different leading indicators have the same predictive power for currency crises in different exchange rate regimes.

Currency crises have a strong impact on the real economy. Hutchison and Noy (2002) use a panel data set over the 1975-1997 period covering 24 emerging economies and find that currency crises reduce output by about 5-8 percent over a two-three year period. In recent decades, the consequences of currency crises have probably worsened due to externalities caused by increased international trade and capital flows. This has encouraged research on leading indicators of currency crises. There is already a wide range of studies in this field, which vary in terms of coverage of countries and time. Most studies on currency crises use either the probit/logit approach proposed by Frankel and Rose (1996) or the signal approach developed by Kaminsky et al. (1998). Previous research comes to diverging conclusions with respect to the predictive power of indicators for currency crises. Most previous studies pool countries and periods. But the disadvantage of pooling data is that it gives various indicators the same weight in potentially different types of currency crises. We try to find out whether there are common patterns in currency crises along various exchange rate regimes.

Figure 4.1 The frequency of currency crises



Note: See Appendix 4.A for the list of countries. Horizontal axis is time.

Using the probit models and the method suggested by Kaminsky et al. (1998) for 88 countries in the 1981-2010 period, our results suggest that countries with the same exchange rate regime tend to share common characteristics before a currency crisis occurs. In fixed exchange rate regimes external economic indicators, such as deviations of the real exchange rate from Hodrick–Prescott filter (HP) trend and growth of international reserves, have the strongest predictive power. In floating exchange rate regimes, monetary policy and credibility indicators, such as domestic credit growth and inflation, are the best indicators of currency crises. Both external economic indicators and credibility indicators have predictive power in intermediate exchange rate regimes. These results suggest that the predictive power of early warning indicators differs across exchange rate regimes, thereby offering some guidance in identifying the vulnerability of countries to a currency crisis.

The structure of this chapter is as follows. Section 4.2 reviews theoretical models of currency crises. Section 4.3 introduces the methodology, while section

4.4 defines the variables used in our analysis. Section 4.5 reports the results and Section 4.6 concludes.

4.2 Literature review

4.2.1 Theoretical models

In this section, we review arguments that have been put forward why the causes of a currency crisis may differ across exchange rate regimes.

According to the "bipolar" view (Fischer, 2001; Crockett, 1994; Eichengreen, 1994), in a world of increasing trade openness and international capital mobility, only two extreme exchange rate regimes, i.e., hard pegs (such as dollarization, currency boards and monetary unions) or freely floating exchange rates, will be able to avoid currency crises and to maintain stability. Intermediate exchange rate regimes (such as conventional pegs, basket pegs, crawling pegs, bands, or managed floating) with open capital accounts are vulnerable to speculative attacks. According to Bordo (2004), the instability of intermediate exchange rate regimes can be explained by the so-called impossible trinity (Mundell, 1963), i.e. the impossibility to have fixed exchange rates, free capital movements and independent monetary policy at the same time. Only a system aiming for two out of three objectives is credible.

Thus, the credibility of the exchange rate regimes is an important factor in triggering currency crises in intermediate exchange rate regimes. There are several empirical studies investigating the link between the fundamentals and the credibility of exchange rate regimes. Rose and Svensson (1994) show that a lower inflation could improve credibility. Ozkan and Sutherland (1998) emphasize the role of high interest rates in generating (or prolonging) a negative demand shock. Such a shock gives rise to expectations in financial markets of the abandonment of the fixed exchange rate, which in turn further increases domestic

nominal interest rates and therefore accelerates the collapse. The lack of credibility may result in a self-fulfilling speculation.

Both first- and second-generation currency crisis models offer useful insights. The first-generation models (Krugman, 1979; Flood and Garber, 1984) start from the assumption of a small economy that fixes its exchange rate while its domestic price level moves in accordance with the foreign price level. The domestic money supply is backed by domestic credit and international reserves. If the government budget deficit grows at a constant rate, the economy will run out of reserves eventually and the fixed exchange rate will break down. So a higher stock of reserves and a lower budget deficit reduce the probability that a fixed exchange rate regime will collapse.

In addition, in this type of models, expansionary policies lead to higher domestic demand for both traded and non-traded goods. The former leads to a deterioration of the trade balance while the latter leads to a real appreciation of the currency. Thus, the real exchange rate can also be used as leading indicator of currency crises according to first-generation models.

Second-generation models, such as the one presented by Obstfeld (1994), rely on different mechanisms. In these models, the government decides whether or not to defend a pegged exchange rate by making a tradeoff between short-run macroeconomic flexibility and longer-term credibility. Doubts about whether the government can maintain its pegged exchange rate lead to multiple equilibria. The crisis arises when defending parity becomes expensive and markets believe that such a defense will ultimately fail. A speculative attack on a currency can be either the result of a predicted future deterioration in fundamentals, or a self-fulfilling prophecy. Thus, in the second-generation currency crisis models, the (expected) deterioration of various economic fundamentals are key indicators of an impending currency crisis.

The third-generation models link financial intermediaries and asset prices to the emergence of a currency crisis. Hausmann et al. (1999) suggest that financial crises in developing and emerging markets have their root in the so-called "original sin" of financial markets. On the one hand, domestic enterprises cannot borrow domestic currency in international capital markets. On the other hand, the financial sector is reluctant to grant long-term loans. This leads domestic investors to face either currency mismatches or maturity mismatches. The currency or maturity mismatches in floating exchange rate regimes may bring about bankruptcy since a depreciation restricts the firms to repay the debts, while in fixed exchange rate regimes currency or maturity mismatches make an economy particularly sensitive to a sovereign default as a result of exhausted reserves.

Aghion et al. (2001) argue that currency crises occur both under fixed and flexible exchange rate regimes since the primary source of a crisis is the deteriorating balance sheet of private firms. If nominal prices are 'sticky', an initial currency depreciation leads to an increase in the foreign currency debt repayment obligations of firms, and thus to a fall in their profits. This reduces firms' borrowing capacity and therefore investment and output in a credit-constrained economy. In turn, this reduces the demand for the domestic currency and leads to a currency crisis. In the models of Hausmann et al. (1999) and Aghion et al. (2001), foreign currency debt is an important indicator of currency crises.

Chang and Velasco (2001) argue that currency crises can be regarded as a byproduct of a bank run as described in Diamond and Dybvig (1983), where a self-fulfilling loss of confidence forces financial intermediaries to liquidate their investments prematurely. Hence, indicators of banking system vulnerability can be used as early warning signals for currency crises.

4.2.2 Empirical studies

Two methods have been widely used in empirical studies on leading indicators of currency crises, namely a probit model from Frankel and Rose (1996) and the KLR method from Kaminsky et al. (1998). Frankel and Rose (1996) were the first to employ probit models. Using annual data for 105 developing countries for the 1971-1992 period, they find that crises tend to occur when output growth is low and domestic credit growth and foreign interest rates are high. A low ratio of FDI to debt is also associated with a high likelihood of a currency crisis. Several subsequent studies also use probit (or logit) models. For example, Kruger et al. (2000) use annual data for 19 developing countries spanning the 1977-1997 period. They report that the current account deficit is the only variable that can be consistently linked to currency crises. Kumar et al. (2003) use logit models for 32 developing countries for the 1985-1999 period. They conclude that declining reserves, exports, and weakening real activity are the most important explanatory variables for currency crashes. Komulainen and Lukkarila (2003) examine the causes of currency crises in 31 emerging market countries during 1980–2001 in a probit model. They conclude that traditional variables, such as unemployment and inflation, as well as indicators of indebtedness, such as private sector liabilities and foreign liabilities of banks, explain crises quite well. Jacobs et al. (2008) apply factor analysis to combine indicators in a logit model. They find that money growth, national savings, and import growth result in currency crises.

The second widely used method has been proposed by Kaminsky et al. (1998), henceforth KLR, who examine 76 currency crises in a sample of 15 developing and 5 industrial countries during the 1970-1995 period. In this method, every indicator receives an optimal threshold value, derived from historical data, minimizing the noise-to-signal ratio (see section 4.3 for details). Variables that these authors report to have the best track record include exports, deviations of the real exchange rate from trend, the ratio of broad money to gross

international reserves, output, and equity prices. The KLR method has been applied in several subsequent studies as well. For instance, Brüggemann and Linne (2002) analyze the vulnerability of Central and Eastern Europe, Turkey and Russia from January 1993 to September 2001 to currency crisis. They find that the overvaluation of the real exchange rate, weak exports, and dwindling currency reserves have predictive power to assess crisis vulnerability. Likewise, Edison (2003) examines crises in twenty developed and emerging market economies. He finds the following indicators of crisis vulnerability: a marked appreciation of the real exchange rate, a high ratio of short-term debt to reserves, a high ratio of M2 to reserves, substantial losses of foreign exchange reserves, and sharply declining equity prices.

The conclusions of these empirical studies regarding the leading indicators of currency crises differ, which may be due to the presence of different sets of explanatory variables, different data frequency, and different models employed. Most previous empirical studies on leading indicators of currency crises pool the data. An exception is Berg et al. (2008), who question the implicit assumption that crises are homogenously caused by identical factors. These authors estimate different logit models using data for 13 countries from South America and South-East Asia for the 1985-2004 period. Their results suggest that the assumption that all countries can be pooled has to be rejected. In addition, Kamin (2001) and Edison (2003) find some differences across regions, also questioning the homogeneity assumption.

Previous empirical studies have not considered the impact of exchange rate regimes although the theoretical models discussed in section 4.2.1 suggest that the mechanisms leading to currency crises may depend on the exchange rate regime in place. However, as far as we know, this issue has not been systematically examined in previous studies.

4.3 Methodology

As discussed in the previous section, there are two widely used methods for identifying leading indicators of currency crises, namely probit (or logit) models and the KLR method. To ensure that our results are not driven by the choice of one particular method, we will use them both. As will be discussed below, both methods have advantages and disadvantages and by using both methods we aim to come up with robust results. This section explains both approaches in more detail.

We first estimate probit models in which the dependent variable Y is a dummy which is unity if a currency crisis takes place and zero if not.

$$\Pr(Y = 1 \mid X) = \Phi(X'\beta + \varepsilon)$$

where Pr is probability, X corresponds to the set of indicators, and β is a vector of maximum likelihood estimates. The probit model assumes that the probability distribution function (Y conditional on X) follows the normal distribution.

Secondly, we use the method proposed by Kaminsky et al. (1998) and Kaminsky and Reinhart (1999) in which every indicator receives an optimal threshold value, derived from historical data, minimizing the noise-to-signal ratio. The definition of the noise-to-signal ratio can be illustrated by the following matrix:

Table 4.1 Noise-to-signal ratio matrix

	Crisis occurs in the following 24 months	No crisis occurs in the following 24 months
Indicator issues a signal	A	B
Indicator does not issue a signal	C	D

If an indicator issues a signal and a crisis occurs in the following 24 months (cell A), the signal is considered to be accurate. The same holds in cell D where the indicator does not give a signal and a crisis does not occur. If the indicator issues a signal but no crisis occurs in the following 24 months (cell B), the signal is considered to be a false alarm or noise. Likewise in cell C, a crisis occurs even though the indicator does not give a signal. Hence, the noise-to-signal ratio for the indicator is given by [B/ (B+D)]/ [A/ (A+C)]. The optimal threshold for a certain indicator is determined where the noise-to-signal ratio is the lowest. The lower the noise-to-signal ratio, the higher the ability of the indicator is to forecast currency crises.[25]

The disadvantage of probit models is that the number of crises is usually small in comparison with the number of tranquil periods. As a result, the statistical properties of limited dependent regressions are often poor. A drawback of the Kaminsky et al. (1998) method is that it does not allow assessing statistical significance. Furthermore, probit models are generally based on annual data, but in the Kaminsky et al. (1998) method generally monthly data are employed. While annual data are available for a larger set of indicators, monthly data may better capture the variability of indicators. We therefore use both methods and data frequencies in our research.

4.4 Data

4.4.1 Currency crises

A variety of approaches have been used to identify currency crises. We follow Frankel and Rose (1996), since it is one of the most widely used ways to define currency crises. These authors consider that a currency crisis occurs if a currency

[25] See Candelon et al. (2012) for a discussion of how to weight type I and type II errors.

depreciates by at least 25 percent annually while there is also at least a 10 percent-point increase in the rate of depreciation.[26] However, instead of using the US dollar exchange rate, we use the change in the SDR exchange rate to mitigate the influence from the US Dollar on currency fluctuations (see also Rose and Spiegel, 2009, 2011 and Gagnon, 2009). We exclude crises which occurred within 3 years of the preceding crisis to avoid counting the same crisis twice as suggested by Frankel and Rose (1996) and Milesi-Ferretti and Razin (2000).

4.4.2 Exchange rate regimes

Several empirical studies on exchange rate regimes use the IMF's de jure classification of exchange rate regimes. However, Calvo and Reinhart (2002) find that, in practice, many exchange rate regimes differ from their de jure classification. We therefore use the de facto classification of exchange rate regimes as suggested by Reinhart and Rogoff (2004) and updated by Ilzetzki et al. (2011), which covers data from 1946 until 2010. It is based on market determined exchange rates rather than official exchange rates. The authors distinguish six categories of exchange rate regimes. The first category includes no separate legal tender, pre-announced peg or currency board arrangement, pre-announced horizontal band that is narrower than or equal to ±2%, and de facto peg. The second category includes the pre-announced crawling peg, the pre-announced crawling band that is narrower than or equal to ±2%, the de facto crawling peg, and the de facto crawling band that is narrower than or equal to ±2%. The third category covers the following regimes: pre-announced crawling band that is wider than or equal to ±2%, de facto crawling band that is narrower than or equal to ±5%, moving band that is narrower than or equal to ±2%, and

[26] We also use 5%, 10% and 15% monthly depreciation to identify currency crises (Kumar et al., 2003). These tests give similar results as in our main text.

managed floating. The fourth category includes freely floating exchange rates, while the fifth one captures freely falling exchange rates (inflation is more than 40%). The final category is the regime with a dual market in which parallel market data is missing. We exclude the fifth and sixth category and divide the remaining four categories into three regimes: fixed, intermediate and floating regimes. The fixed exchange rate regimes are those in the first category of Ilzetzki et al. (2011). The intermediate exchange rate regimes include the second and third categories, while the floating exchange rate regimes are those in the fourth category.

We use data of 88 countries for the 1981-2010 period. The countries are listed in Appendix 4.A. For these countries, the data is available for the period under consideration. Our sample contains 218 currency crises of which 31, 118 and 18 occurred in fixed, intermediate and floating regimes, respectively (on 51 occasions, the exchange rate regime is not available, see Appendix 4.A for details).

4.4.3 Explanatory variables

Based on the literature review in section 4.2, we have selected several early warning indicators.

The first-generation currency crisis models emphasize the instability of the fixed exchange rate when the government follows expansionary fiscal policies and foreign reserves are deficient. The indicators considered include the *government budget deficit* (Eichengreen, 1995; Kruger, 2000) and the *growth rate of foreign reserves* (Eichengreen et al., 1995; Kaminsky and Reinhart, 1999). We use the change of general government debt to GDP as an indicator of the government's budget deficit (see also Roubini and Sachs, 1989). We expect that the sign of the budget deficit is positive and that of the growth of foreign reserves is negative.

The second-generation currency crisis models focus on the decision-making of the government, which has to weigh the costs and benefits of maintaining a fixed exchange rate regime. The indicators we select include *unemployment* (Eichengreen et al., 1995; Krugman, 1996), *exports* (Eichengreen et al., 1995; Kaminsky and Reinhart, 1999; Edison, 2003; Kumar et al., 2003), *deviation of real exchange rate from trend* (Kaminsky and Reinhart, 1999; Kruger, 2000), *interest rate differential* (Kaminsky et al., 1998; Komulainen and Lukkarila, 2003), *GDP growth* or *industrial output growth* (Eichengreen et al., 1995; Kaminsky and Reinhart, 1999; Kumar et al., 2003; Lau and Yan, 2005) and *inflation* (Eichengreen et al., 1995; Krugman, 1996).

The expected sign of unemployment is positive. Higher unemployment pressures the government to depreciate in order to create job opportunities. The effect of the growth rate of exports is expected to be negative. A higher growth rate of exports may reflect more competitiveness which, in turn, reduces the probability of a currency crisis. The impact of the deviation of the real exchange rate from its trend (determined by a Hodrick–Prescott filter, see Goldfajn and Valdes, 1998) is expected to be negative. An appreciation results in declining competitiveness which may lead to pressure on the currency. A high interest rate differential signifies a higher risk premium which may increase the probability of a currency crisis. The expected sign of the GDP growth rate is negative, as a better economic performance will reduce the likelihood of a currency crisis. A higher inflation is associated with higher realignment expectations. The expected sign of inflation is therefore positive.

The third-generation currency crisis models relate to several theories, namely 'original sin' theory, balance sheet theory, moral hazard models, and twin crises theory (Eichengreen et al., 2003). In line with the 'original sin' theory and balance sheet theory from Aghion et al. (2001), we include total *external debt to exports* and *short-term debt to foreign reserves*, which are both indicators

of currency mismatch. The higher these indicators, the higher the probability of a currency crisis will be.

The moral hazard models of the third-generation currency crisis models emphasizes the variability of domestic prices and interest rates in floating regimes. The variability of domestic prices and interest rates are related to monetary policy. The indicators inspired by this model are *M2 growth* (Aziz, 2000; Glick and Hutchison, 2001), and *domestic credit growth* (Eichengreen et al., 1995; Kruger, 2000). The expected sign of these indicators is positive.

The *US interest rate* is chosen to capture the role of high interest rates in the center country as mentioned in Ozkan and Sutherland (1998). The effect of the US interest rate is expected to be positive. A high interest rate in the center country may generate (or prolong) a negative demand shock in the domestic economy.

In addition, banking system vulnerability is important in some third-generation currency crisis models (for example, Chang and Velasco, 2001). To capture this, we follow Kaminsky and Reinhart (1999) and Edison (2003) and include the *lending rate to deposit rate*. It is an indicator of the profitability of the banking system (Cerra and Saxena, 2002).

All in all, we have 14 indicators; Appendix 4.B provides details and data sources. These indicators can be categorized as follows: external indicators (real exchange rate, growth of exports, foreign reserves, the US interest rate, external debt and short-term foreign debt), real sector indicators (GDP growth, unemployment and the government budget deficit), credibility indicators (inflation and interest rate differential), monetary policy indicators (domestic credit and M2 growth) and banking sector vulnerability (lending to deposit rate). The correlation matrixes for the indicators are shown in Appendix 4.C (both monthly and annual data).

4.5 Empirical results

As data availability would diminish the number of observations in multivariate models drastically, we focus on simple bivariate probit models in the main text. The dependent variable is a dummy which is 1 in case a currency crisis occurs according to the definition of Frankel and Rose (1996). The explanatory variables have been explained in the previous section. Table 4.2 shows the results of the bivariate regressions for different exchange rate regimes. The number of observations differs for each model, depending on data availability.

Table 4.2 Marginal effects in bivariate probit models for different exchange rate regimes

	Fixed	No. obs.	Intermediate	No. obs.	Floating	No. obs.
Deviation of real exchange rate from trend	0.0016*** (5.29)	452	0.0011*** (2.87)	737	-0.0006** (-2.40)	137
Interest rate differential	0.0035*** (3.83)	402	0.0055** (4.73)	552	0.0084** (2.57)	120
GDP growth	-0.0034*** (-3.32)	961	-0.0030 (-1.34)	1182	0.0006 (0.16)	160
External debt to export	0.0001*** (3.10)	712	0.0001*** (3.28)	860	-0.0003 (-0.90)	62
Lending rate to deposit rate	-0.0086*** (-2.81)	728	-0.0219** (-2.41)	971	-0.0148 (-0.79)	115
Foreign reserves growth	-0.0237*** (-2.63)	956	-0.0914*** (-3.69)	1201	0.0020 (0.10)	155
Export growth	-0.2495* (-1.93)	124	-0.0579 (-0.62)	585	0.3984 (1.54)	102
Government budget deficit to GDP	0.0007* (1.70)	273	-0.0002 (-0.17)	427	0.0010* (1.66)	101
Domestic credit growth	-0.0312 (-1.15)	924	0.0323* (1.83)	1171	0.2465** (2.5)	125
Unemployment	-0.0015 (-0.69)	216	0.0006 (0.32)	626	0.0054** (2.30)	102
US interest rate	-0.0010 (-0.59)	981	0.0052** (2.04)	1242	0.0082 (0.89)	160
Short-term foreign debt to foreign reserves	3.48e-07 (0.53)	746	0.00002* (1.96)	847	4.91e-07 (0.85)	74
M2 growth	-0.0002 (-0.51)	962	0.0020*** (3.79)	1168	0.0051*** (3.29)	131
Inflation	0.00007 (0.38)	880	0.0040*** (5.42)	1198	0.0007* (1.74)	156

Note: The standard error for each variable is shown in parentheses, * significant at 10%, ** significant at 5%, *** significant at 1%. The entries refer to marginal effects at the mean.

The results of the bivariate regressions for different exchange rate regimes in Table 4.2 suggest that several drivers of currency crises are different among the

exchange rate regimes. Looking across the various variables, the real exchange rate and the interest rate differential appear statistically significant independent of the exchange rate regime in place. The relationship between the real exchange rate deviation and the probability of having a currency crisis is significantly positive in fixed and intermediate regimes, but significantly negative in floating regimes. The latter finding is also reported by Mussa (1986) who claims that the variability of real exchange rates is largely accounted for by the variability of nominal exchange rates in floating regimes. Thus the real exchange rate is expected to move in the same direction as the nominal exchange rate in floating exchange rate regimes. But in fixed and intermediate exchange rate regimes, a real exchange rate appreciation decreases a country's competitiveness. Therefore, it increases the probability of a currency crisis. The interest rate differential has the anticipated sign across all regimes: a higher interest rate differential is associated with higher crisis incidence.

Apart from the real exchange rate, the external sector indicators include the growth of exports, foreign reserves, the US interest rate, external debt and short-term foreign debt. The probability of a currency crisis is negatively associated with export growth in fixed regimes, positively associated with the US interest rate in intermediate regimes, and negatively associated with foreign reserves in both fixed and intermediate regimes as we expected. In addition, both external debt to export and short-term foreign debt to foreign reserve appear as useful leading indicator in fixed and intermediate regimes and in intermediate regimes respectively. In all, none of the external sector indicators is significant in floating regimes, except for the real exchange rate.

The real sector indicators consist of GDP growth, unemployment and the government budget deficit to GDP. The probability of a currency crisis is associated with a fall in GDP growth and an increase in both unemployment and

the government budget deficit. A decline in real sector activity is significant in both fixed and floating regimes, but is insignificant in the intermediate regimes.

The credibility indicators include inflation and the interest rate differential. Both are significant in the intermediate and the floating regimes.

The monetary policy indicators are domestic credit and M2 growth. A rise in credit is associated with greater probability of currency crises in intermediate and floating regimes.

The lending to deposit rate is an indicator of banking sector profitability. It is significant in both fixed and intermediate regimes. The results suggest that an increase of the lending rate to deposit rate decreases the probability of a currency crisis.

To examine whether our results are different in a multivariate context, we also have estimated multivariate probit models using the general-to-specific method (Ericsson et al., 1991 and Pagan, 1987). The results of the multivariate probit models are shown in Appendix 4.D.

In sum, the results above are in line with the findings of previous studies that the real exchange rate is one of the most useful leading indicators of currency crises. The interest rate differential is also useful for predicting currency crises. Our results suggest that the exchange rate regime in place matters. The external indicators are found to be helpful in explaining currency crises in fixed and intermediate regimes (Krugman, 1979; Obstfeld, 1994). High credit growth and lack of credibility are associated with a higher incidence of currency crisis in intermediate and floating regimes (Bordo, 2004; Hausmann et al., 1999; Chang and Velasco, 2001). The multivariate models using the general-to-specific method (shown in Appendix 4.D) confirm these results.

Finally, we follow the Kaminsky et al. (1998) approach to confirm the validity of our findings. We use monthly data for 88 countries. Unfortunately, monthly data are not available for all variables considered. Since GDP is not

available at a monthly frequency, we use industrial production instead. We also lack monthly data for the short-term debt to foreign reserves, external debt to exports, government deficits and unemployment. For these variables we could not find reasonable substitutes. The results of the KLR method are shown in Table 4.3.

Table 4.3 Results of the KLR method

	(1) Fixed exchange rate regime		(2) Intermediate exchange rate regime		(3) Floating exchange rate regime	
Indicators:	Ratio	Threshold	Ratio	Threshold	Ratio	Threshold
Deviation of real exchange rate from trend	0.48	0.79	0.38	0.90	0.65	0.10
Interest rate differential	0.37	0.61	0.56	0.72	0.60	0.58
Industrial production growth	0.64	0.30	0.50	0.16	0.82	0.37
Lending rate to deposit rate	0.50	0.31	Na	0.25	0.35	0.18
Foreign reserves growth	0.48	0.28	0.59	0.18	0.25	0.09
Export growth	0.84	0.44	0.49	0.08	0.54	0.18
Domestic credit growth	0.88	0.40	0.55	0.70	0.26	0.74
US interest rate	0.80	0.40	0.56	0.65	0.11	0.80
M2 growth	0.59	0.71	0.51	0.75	0.55	0.69
Inflation	0.30	0.82	0.36	0.88	0.43	0.78

Note: Ratio is the noise-to-signal ratio. Na signifies that data are deficient.

Reviewing the results in Table 4.3, it appears that the inflation has a noise-to-signal ratio less than 0.5 (the threshold with 0.5 is derived from Lin et al., 2008) in all regimes. The lower the noise-to-signal ratio is, the more useful of an indicator in forecasting crisis. Kaminsky et al. (1998) and Berg and Pattillo (1999) use a noise-to-signal ratio less than 1. Hence, our criterion is more strict.

The results in column (1) show that there are four indicators with low noise-to-signal ratio in fixed exchange rate regimes: the deviation of the real

exchange rate from trend, interest rate differential, foreign reserves and inflation. The currency crises in fixed regimes are strongly associated with an appreciation of the real effective exchange rate, an increasing interest rate differential, an exhaustion of foreign reserves and rising inflation. These results are consistent with the probit results according to which notably the external indicators are significant in the models for fixed exchange rate regimes.

Column (2) in Table 4.3 shows that there are three indicators with low noise-to-signal ratio in the intermediate exchange rate regimes: the deviation of the real exchange rate from trend, exports and inflation. These results are broadly in line with the probit results. Inflation seems to be one of the most reliable early warning indicators of a currency crisis in intermediate regimes. This is in line with Rose and Svensson (1994), who claim that lower inflation improves credibility, which decreases the probability of having a currency crisis.

There are five indicators that successfully warn for currency crises in floating exchange rate regimes according to the KLR model: lending to deposit rate, reserves growth, domestic credit growth, US interest rate, and inflation (column 3 of Table 4.3). The inflation and domestic credit were also significant in the probit model. In other words, both approaches suggest that the decrease of credibility and the expansion of monetary policy are main drivers of currency crises in floating exchange rate regimes. The empirical findings for the floating regimes suggest that a currency crisis in this type of regime were not so much associated with a deterioration of the external sector; also a slowdown in GDP is not a good leading indicator.

Comparing the results of the KLR approach and those of the probit analysis (see Table 4.4, the variables for which we lack monthly data are notified by "—"), the real exchange rate stands out as a useful leading indicator in fixed and intermediate exchange rate regimes. This result is in line with the findings of most previous studies (Kaminsky et al., 1998; Brüggemann and Linne; 2002;

Edison, 2003; Klein and Marion, 1994; Alvarez-Plata and Schrooten, 2004; Feridun, 2004).

The results for the interest rate differential in both models are consistent, i.e. the indicator is useful in explaining currency crises in fixed regimes. Likewise, inflation is always significant in explaining currency crises in intermediate and floating regimes. Also foreign reserves in fixed regimes and domestic credit growth in floating regimes are robust to the choice of a particular methodology. Still, there are some differences between both approaches. For instance, GDP growth, exports and the US interest rate are significant in fixed regimes, the interest rate differential is significant in intermediate and floating exchange rate regimes, and M2 growth is significant in floating regimes when we use probit models. Inflation has a low noise-to-signal ratio in fixed regimes, export has a low noise-to-signal ratio in intermediate regimes, and reserves, the US interest rate and the lending to deposit rate have low noise-to-signal ratios in floating regimes in the KLR models.

Table 4.4 Summary results of probit models and KLR models

	Fixed exchange rate regime		Intermediate exchange rate regime		Floating exchange rate regime	
	Probit	KLR	Probit	KLR	Probit	KLR
Deviation of real exchange rate from trend	***	*****	***	**	**	
Interest rate differential	***	**	**		**	
Inflation		**	***	**	*	*
Foreign reserves growth	***	*	***			***
GDP growth/Industrial production growth	***					
Lending rate to deposit rate	***		***	**		**
Export growth	*			*		
M2 growth			***		***	
US interest rate			**			****
Domestic credit growth			*		**	***
External debt to export	***	——	***	——		——
Government budget deficit	*	——		——	*	——
Short-term foreign debt to foreign reserves		——	*	——		——

Note: In probit model: * significant at 10%, ** significant at 5%, *** significant at 1%. In KLR method: ***** signifies noise-to-signal ratios <0.1, **** signifies 0.1<noise-to-signal ratios <0.2, *** signifies 0.2<noise-to-signal ratios <0.3, ** signifies 0.3<noise-to-signal ratios <0.4, * signifies 0.4<noise-to-signal ratios <0.5, —— signifies no data available.

So it appears that the choice of methodology matters, as they do not yield exactly the same outcomes. Nevertheless, the importance of certain factors seems to be robust across different methodologies. Our results suggest that external economic indicators (and fiscal deficits) are key leading indicators of currency crises under fixed exchange rate regimes, while monetary policy indicators are not significant in fixed regimes. The reason is that expansionary monetary policies may not immediately lead to currency crises as long as foreign reserves are sufficient in the fixed exchange rate regimes (Connolly, 1986). In floating exchange rate regimes monetary policy and credibility indicators are the best leading indicators of currency crises. Both credibility and external economic

indicators have predictive power in intermediate exchange rate regimes. Our results confirm Burnside et al., (2001), who show that the presence of government guarantees (fixed exchange rate) and the associated fiscal implications of bank bailouts lead to the possibility of self-fulling currency crises.

4.6 Conclusions

In this chapter, we extend previous studies by analyzing the extent to which currency crises share common characteristics in fixed, intermediate and floating regimes. The most important finding of this chapter is that both probit models and the approach suggested by Kaminsky et al. (1998) suggest that the leading indicators of currency crises differ across exchange rate regimes. In fixed exchange rate regimes, there is a marked deterioration in external indicators, such as deviations of the real exchange rate from trend and the growth of international reserves, before currency crises. Indicators that prove to be useful in anticipating crises in floating exchange rate regimes are credibility and monetary policies indicators, such as inflation and domestic credit growth. Both credibility and external economic indicators have predictive power in intermediate exchange rate regimes.

Our study has some limitations. Even though we have considered several indicators, we may have omitted some relevant variables, such as political and institutional indicators (see Glick and Hutchison (2005) for a detailed discussion). We exclusively concentrate on economic indicators. In addition, we focus on these indicators in isolation, while it is possible that some combinations of variables may cause higher vulnerability to currency crises (Garcia and Valpassos, 1998).

The variation in the early warming indicators for different exchange rate regimes suggests that future research into the causes of currency crises, and into

the leading indicators of predicting future crises, should keep differences in exchange rate regimes in mind. One suggestion for future research is to examine whether this also holds for banking and sovereign debt crises.

Appendix

4.A Currency crises and exchange rate regimes

Country	Currency crisis	Country	Currency crisis	Country	Currency crisis
Algeria	1994 Jun(2)	Guatemala	1990 Feb()	New	2008 Nov(2)
	1991 Jun(2)		1986 Jun()	Zealand	1998 Jun(2)
	1988 Jun(2)	Guinea	2008 May(2)		1984 Aug(2)
Argentina	2009 Sep(2)		2004 Aug(2)	Niger	1994 Jan(1)
	2002 Jan(1)		1998 Jul(2)	Nigeria	2009 Aug(2)
	1987 Jul()		1992 Apr(2)		1999 Jan(2)
	1984 Jul()		1986 Jan()		1992 Mar()
	1981 Apr(2)	Haiti	2003 Sep(1)		1989 Jan(3)
Australia	2008 Oct(3)		2000 Sep(3)		1985 Oct()
	1985 Apr(3)		1994 Sep()	Paraguay	2009 Sep(2)
Benin	1994 Jan(1)		1991 Sep(2)		2001 Sep(2)
Bolivia	1990 May(2)	Honduras	1994 Feb(2)		1998 Apr(2)
	1985 Dec()		1990 Mar(2)		1992 Aug(2)
	1982 Dec()	Iceland	2008 May(2)		1987 Jun(2)
Botswana	2008 Oct(2)		2001 May(2)		1984 Jun(2)
	1998 Sep(2)		1993 Jul(2)	Peru	1993 Oct()
	1993 Jun(2)		1989 Jan(2)		1990 Oct()
	1985 Jan(2)		1985 May(2)		1987 Oct()
Brazil	2008 Dec(2)		1981 Feb()		1983 Oct()
	2002 Nov(2)	India	1991 Jul(2)	Philippines	1997 Dec(1)
	1999 Jan(2)	Indonesia	2001 Feb(2)		1990 Sep(2)
	1992 Mar()		1997 Oct(2)		1986 Jul(2)
	1988 Apr()		1986 Sep(2)		1983 Jul(2)
	1985 Apr()		1983 Apr(2)	Senegal	1994 Jan(1)
	1981 Dec()	Iran	2002 Mar(2)	South	2008 Oct(3)
Burkina Faso	1994 Jan(1)		1993 Mar(2)	Africa	2001 Nov(3)
Cameroon	1994 Jan(1)	Israel	1984 Jan()		1998 Jul(3)
Central	1994 Jan(1)		1981 Jan()		1984 Jul(2)
African					
Chad	1994 Jan(1)	Jamaica	2009 Oct(2)	Surinam	2003 Jan(1)
Chile	2008 Dec(2)		2003 Mar(2)		1999 Feb()
	1990 Nov(2)		1993 Nov()		1994 Jan()
	1985 Aug(2)		1990 Feb(2)	Swaziland	2008 Oct(1)
	1982 Aug(1)		1983 Dec(1)		2001 Nov(1)
Hong Kong	1983 Sep(2)	Jordan	1992 Nov(2)		1998 Jul(1)

Columbia	2002 Oct(2)	Kenya	1999 Aug(2)		1984 Jul(1)
	1998 Apr(2)		1995 Oct(2)	Sweden	2009 Feb(2)
	1990 Jan(2)		1992 Sep(2)		1993 Feb(2)
	1985 Apr(2)		1985 Mar(1)		1982 Nov(2)
Democratic	2009 Jan(3)	Korea	2008 Oct(2)	Tanzania	1992 Sep(2)
Republic of	2004 Dec(3)		1997 Dec(2)		1989 Sep(2)
Congo	2001 Oct(3)	Lebanon	1990 May()		1986 Jul(2)
	1998 Oct()		1986 Dec()		1983 Jul(2)
	1995 Jan()		1983 Dec(2)	Thailand	1997 Sep(1)
	1992 Jan()	Liberia	2004 Nov(3)	Togo	1994 Jan(1)
	1989 Jan()		2001 Jul(3)	Tunisia	1986 Sep(2)
	1985 Oct()		1998 Jan()	Turkey	2008 Nov(3)
	1982 Mar()	Libya	2002 Jan()		2001 Apr(2)
Republic of	1994 Jan(1)		1994 Oct(2)		1998 Jan()
the Congo					
Costa Rica	1995 Apr(2)		1986 Mar(2)		1995 Jan()
	1990 Sep(2)	Madagascar	2004 Mar(2)		1992 Jan()
	1986 Jan(2)		1997 Aug(2)		1989 Jan()
	1981 Jan(1)		1994 Jun(2)		1986 Jan()
Dominican	2002 Nov(2)		1991 Jun(2)		1982 Feb(2)
Republic	1991 Jan()		1986 Aug(2)	Uganda	2009 May(2)
	1988 Jan(2)		1982 Sep(1)		1990 Jul(1)
	1985 Jan(2)	Malawi	2004 Jul(2)		1987 Jun()
Egypt	2003 Feb(1)		2001 Jun(2)		1984 Jun(3)
	1989 Aug(2)		1998 Jun(1)		1981 Jun(2)
El Salvador	1990 May(2)		1995 Jun()	United	2008 Nov(2)
	1986 Jan(2)		1992 Jun(3)	Kingdom	1993 Aug(1)
Equatorial	1994 Jan(1)		1985 Apr(3)	Uruguay	2002 Apr(2)
Guinea					
Gabon	1994 Jan(1)	Malaysia	1997 Nov(2)		1995 Jul()
Gambia	2002 Jun(2)	Mali	1994 Jan(1)		1992 Jul(2)
	1984 Apr()	Mexico	2009 Feb(2)		1989 Jul()
Ghana	2009 Feb(2)		2003 Jan(2)		1985 Dec()
	2003 Jan(2)		1998 Sep(2)		1982 Dec(2)
	1999 Nov(2)		1994 Dec(1)	Venezuela	2010 Feb(1)
	1996 Jan()		1990 Sep(2)		2002 Mar(2)
	1993 Jan(2)		1985 Jul()		1996 Mar()
	1990 Jan(3)		1982 Mar(2)		1993 Mar(2)
	1986 Oct(3)	Morocco	1981 Jul(2)		1990 Mar(2)
	1983 Oct()	Nepal	1991 Jul(2)		1987 Mar(2)
			1985 Dec(2)		1984 Mar(2)

Note: Antigua and Barbuda, Bahamas, Barbados, Belize, Canada, Denmark, Djibouti, Dominica, Grenada, Japan, Mauritius, Myanmar, Norway, Panama, Saudi Arabia, Singapore, Sri Lanka, St. Lucia, St. Vincent and the Grenadines, Switzerland, and United States did not have a currency crisis in the periods 1981-2009. (1) signifies fixed exchange rate regime, (2) is intermediate exchange rate regime, (3) indicates floating exchange rate regime. () means data is not available.

4.B Data description

	Source:	
Real exchange rate deviation	IFS	Deviation from Hodrick–Prescott filter (HP)
GDP growth	WDI	GDP growth (annual %)
Export growth	IFS	Goods, volume of exports (Percent change over corresponding period of previous year)
Lending rate to deposit rate	IFS	Lending rate divided by deposit rate
Foreign reserve growth	IFS	Official reserve assets (Percent change over corresponding period of previous year)
External debt to export	WDI	External debt stocks (% of exports of goods, services and primary income)
Short-term foreign debt to foreign reserve	WDI	Short-term debt (% of total reserves)
General government debt to GDP	WDI	Annual change of general government net debt
Unemployment	IFS	Unemployment rate
US interest rate	IFS	Government securities, treasury bills
Interest rate differential	IFS	Government securities, treasury bills minus Government securities, treasury bills in US
M2 growth	IFS	Money plus quasi-money (Percent change over corresponding period of previous year)
Inflation	IFS	Consumer prices, all items (Percent change over corresponding period of previous year)
Domestic credit growth	IFS	Claims on private sector (Percent change over corresponding period of previous year)
Industrial production	IFS	Percent change over corresponding period of previous year

Note: We use lambda = 100 for annual data and 14400 for monthly data in HP Filter.

4.C Correlation matrix

4.C.1 Correlation matrix using annual data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Real exchange rate deviations from trend (1)	1													
Interest rate differential (2)	-0.0104	1												
GDP growth (3)	-0.07	-0.048	1											
External debt to export (4)	0.0043	0.4172	-0.1471	1										
Lending rate to deposit rate (5)	0.0039	-0.0653	-0.0177	0.0392	1									
Foreign reserves growth (6)	0.0011	0.0981	0.0115	0.0177	0.0024	1								
Export growth (7)	-0.1408	0.0807	0.2752	-0.0385	-0.0415	0.0057	1							
Government budget deficit to GDP (8)	-0.1056	0.0677	-0.3569	-0.2285	0.0086	-0.0313	-0.015	1						
Domestic credit growth (9)	0.057	0.5446	-0.0566	0.0934	-0.0038	0.0023	-0.0713	-0.1313	1					
Unemployment (10)	-0.0893	0.106	-0.136	-0.0342	-0.0479	0.1032	-0.0332	0.0169	-0.0428	1				
US interest rate (11)	0.0068	0.106	-0.0332	0.0754	-0.0991	-0.0166	0.0612	0.014	0.0116	-0.0905	1			
Short-term foreign debt to foreign reserves (12)	0.029	0.2295	0.2372	0.2275	0.0514	-0.0053	-0.0541	0.0051	0.0032	0.101	-0.007	1		
M2 growth (13)	0.0659	0.6651	-0.0859	0.0988	-0.0062	0.0035	-0.0525	-0.0973	0.8784	-0.0515	0.0286	-0.0045	1	
Inflation (14)	0.0477	0.7908	-0.086	0.0983	-0.0048	0.0062	-0.06	0.0712	0.9721	-0.0413	0.0171	0.0169	0.8689	1

4.C.2 Correlation matrix using monthly data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Real exchange rate deviations from trend (1)	1									
Interest rate differential (2)	0.0016	1								
Industrial production (3)	-0.034	-0.0445	1							
Lending rate to deposit rate (4)	-0.0023	-0.0248	-0.0903	1						
Foreign reserves growth (5)	0.0003	0.0276	0.0605	0.0007	1					
Export growth (6)	0.0041	0.0622	0.4133	-0.007	0.0453	1				
Domestic credit growth (7)	0.0144	0.0026	0.0153	-0.0028	-0.0006	-0.0035	1			
US interest rate (8)	0.0025	-0.0729	0.1359	-0.1026	-0.0025	0.0198	0.0201	1		
M2 growth (9)	-0.0156	0.6273	0.0119	-0.0046	0.0008	-0.0019	0.2877	0.0177	1	
Inflation (10)	-0.0177	0.7273	0.0069	-0.004	-0.0009	-0.009	0.2651	0.0108	0.8611	1

4.D Marginal effects of multivariate probit models for different exchange rate regimes

	Fixed exchange rate regimes	Intermediate exchange rate regimes	Floating exchange rate regimes
Real exchange rate deviation	0.00004*** (3.83)		-0.0007*** (-2.87)
Foreign reserve growth	-0.0015*** (-3.03)	-0.1051*** (-3.78)	
Lending rate to deposit rate	-0.0006* (-1.72)		
Inflation		0.0036*** (3.85)	0.0009** (2.39)
External debt to export		0.00009** (2.09)	
Sample	368	820	136
Log likelihood	-30.7744	-263.1908	-41.3303

Note: This table shows multivariate probit models of currency crises; model specification determined using the general-to-specific approach. * significant at 10%, ** significant at 5%, *** significant at 1%.

Chapter 5

The Relationship between the Renminbi Future Spot Return and the Forward Discount Rate

5.1 Introduction

China is playing an increasingly important role in the international monetary and financial arena. Therefore, its foreign exchange policy is of increasing interest. In this chapter, we specifically analyze the relationship between the Renminbi's future spot return and its forward discount rate. Several studies have examined the relationship between future spot returns and forward discount rates (see the survey by Engel (1996) for early studies and Pippenger (2011) for an overview of more recent studies). Most studies report a forward discount bias, i.e. the slope coefficient in the regression of the change in the future spot rate on the current forward discount is significantly negative instead of being unity. This outcome rejects the forward rate unbiasedness hypothesis (FRUH). This hypothesis holds that the forward rate is an unbiased predictor of the future spot rate (Bai and Mollick, 2010). Landon and Smith (2003) argue that the rejection of the FRUH could occur because market behavior is inconsistent with rational expectations or because of a risk premium. Frankel and Poonawala (2010) report that the forward discount rates in emerging markets are less biased than those in more advanced countries.

In this chapter, we complement Frankel and Poonawala (2010) and examine the impact of the global financial crisis on the relationship between the future spot return and the forward discount rate in China. While previous studies have focused on the major currencies of industrialized countries, this chapter examines the forward discount for China. To the best of our knowledge, the relationship between future spot returns and forward discount rates has not been investigated for China before. The reason probably has been the de facto peg of the Renminbi to the US dollar (Xin, 2004). However, in July 2005 the currency regime was reformed with the result that a foreign exchange market could develop (Colavecchio and Funke, 2008). The Chinese

currency offers a very interesting case to examine the unbiasedness hypothesis, as there are differences in the exchange rate regime in the period under consideration.

It is useful to focus on the Chinese currency developments during the recent global financial crisis, as the volatility of financial markets during a crisis "raises the stakes for financial markets and central banks; it also may provide a more statistically powerful test" (Flood and Rose, 2002, p. 253). There are few papers that investigate the impact of financial crises on the foreign exchange market. Jeon and Seo (2003) analyze the effect of the Asian financial crisis on foreign exchange market efficiency in Thailand, Indonesia, Malaysia and Korea. Using pre-determined breakpoints, they partition the full sample into a crisis and a non-crisis period and conclude that, in contrast to the full sample period, the foreign exchange markets are not efficient in the post-crisis period.

Hansen (1992) and Hansen and Johansen (1999) criticize the use of predetermined breakpoints. Several tests have been developed to determine breakpoints, like those of Zivot and Andrews (1992) and Bai and Perron (1998, 2003). Bai and Mollick (2010) investigate the effect of the Asian crisis of 1997 and the Turkish crisis of 2000 on the forward discount bias in fourteen emerging economies using endogenous multiple structural models. Bai and Mollick (2010) differentiate the crisis periods from the non-crisis periods by endogenous multiple structural breaks tests as suggested by Bai and Perron (1998, 2003) and conclude that the financial crisis has affected the forward discount bias.

In this chapter, we extend the existing literature by presenting empirical evidence about the impact of the recent financial crisis on the relationship between future spot returns and forward discount rates in China. In line with Hansen and Johansen (1999), Rangvid and Sørensen (2002) and Kutan and Zhou (2003), we use rolling cointegration tests to examine the time-varying relationship between the future spot return and the forward discount rather than OLS regressions as used in Bai and Mollick (2010). We find that there were different regimes after this reform and that the financial crisis has affected the relationship between the future spot return and the forward discount rate in China. The unbiasedness hypothesis that the forward rate is an unbiased predictor of the future spot rate requires cointegration and a unity coefficient for the forward discount. We conclude that the unbiased forward rate hypothesis only holds in Spring 2009, when the spot exchange rate was almost

invariant because the Chinese authorities had returned to pegging the Renminbi to the US dollar to overcome the turmoil caused by the global financial crisis

The structure of this chapter is as follows. Section 5.2 provides a brief introduction to recent developments in the Chinese foreign exchange market and offers a selective overview of the literature on the unbiased forward rate hypothesis. Section 5.3 introduces the methodology and the data. Section 5.4 reports and discusses the results of the relationship between future spot return and forward discount rates in China. The final section concludes.

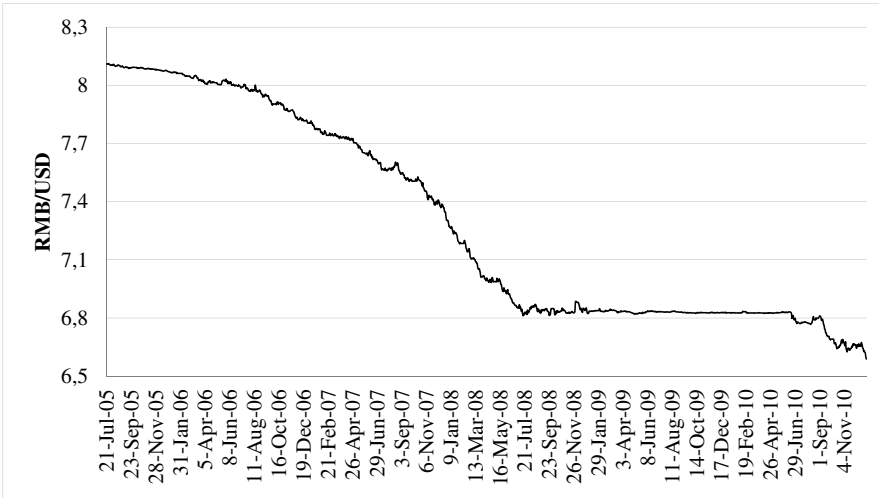
5.2 Background information

In 1994, the Chinese authorities decided to peg the Renminbi (RMB; Yuan is the unit of RMB) to the US dollar. This forced the People's Bank of China (PBOC) into large Forex operations. The PBOC sterilized the impact of Forex interventions on domestic money supply by offsetting sales/purchases of domestic bonds. However, on July 21, 2005, China announced the abolition of its fixed nominal exchange rate to the US dollar. The same day, the Renminbi spot exchange with respect to the US dollar appreciated from 8.27 to 8.11. From then on, the PBOC manages the Renminbi against a basket of currencies of China's main trading partners. After this hallmark, the bilateral exchange rate with the US dollar gradually appreciated until the financial crisis of 2008 (see Figure 5.1).[27] But during the financial crisis, in fact in July 2008, the central bank returned to pegging the Renminbi to the US dollar. The Chinese authorities motivated their decision as part of an effort to overcome the temporary interruption to the reform process that was caused by the global financial crisis. On June 19, 2010 the PBOC announced the return to a managed floating exchange rate regime under which the spot exchange rate can move intraday with at most ±0.5 percent from the central parity. This parity is determined at the opening of the trading day by a truncated weighted average of primary dealers' offer rates and is announced by the China Foreign Exchange Trading System. The central parity itself has not moved by more than ±0.5 percent each day. By the end of 2010, the exchange rate to

[27] Unless indicated otherwise, all data used in this chapter is derived from Thomson Reuter's Datastream.

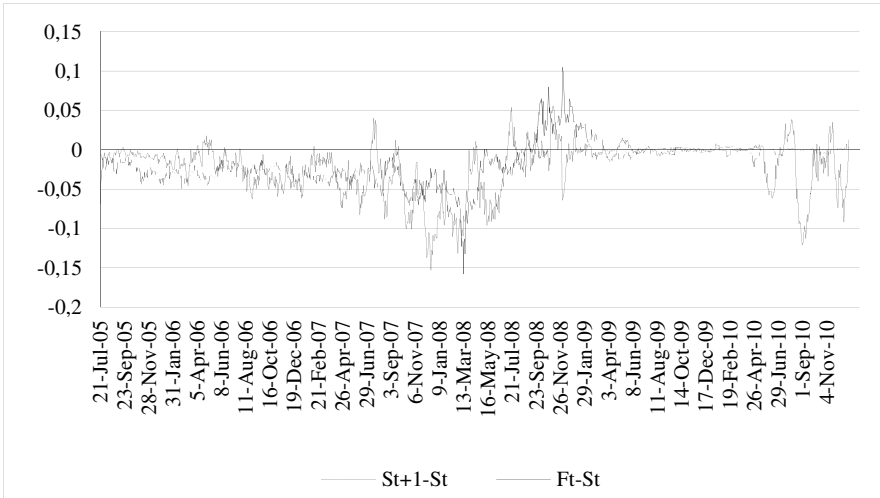
the dollar stood around 6.6. This implies that the Renminbi has appreciated by about 17.5% since the initial reform of July 2005.

Figure 5.1 The RMB spot exchange rate to the US Dollar



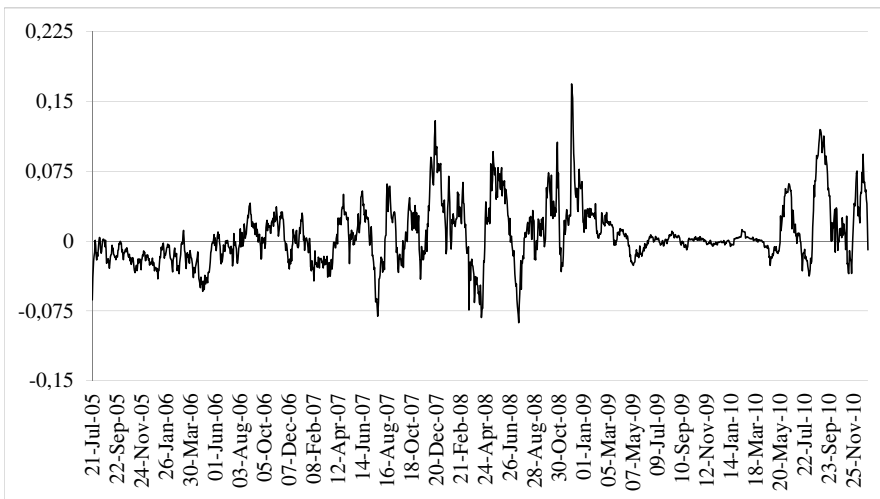
After the exchange rate reform, in tandem with the enormous growth of international trade, foreign exchange trading in China has been booming. Foreign exchange trading in China is carried out by a number of banks and foreign exchange trading agencies. The daily average turnover of foreign exchange market in China has increased from US dollar 1 billion in 2004 to 20 billion in 2010 (BIS, 2010). Figure 5.2 presents the future spot return and one-month forward discount rate from July 21, 2005 to December 31, 2010. It shows that the volatility of the future spot returns and forward discount rate is time varying. The future spot return and the forward discount rate are quite volatile throughout 2007 and 2008. However, between early 2009 until Spring 2010 they hardly move. In the last three quarters of 2010, especially the future spot return becomes volatile again. Figure 5.3 shows the difference between the future spot return and the one-month forward discount rate. This differential reflects the expectation 'bias', which is quite volatile from mid-2007 to end-2008.

Figure 5.2 The future spot return and forward discount rate



Note: S_{t+1} is the future spot rate; S_t is the spot rate; F_t is the forward rate; S_{t+1}- S_t is the future spot return; F_t- S_t is the forward discount rate.

Figure 5.3 The difference between future spot return and forward discount rate



Two methods are widely used to test whether the forward discount predicts the future spot return. First, Ordinary Least Squares regressions have been used to test whether the forward discount is an unbiased predictor of the future spot return if

agents are risk neutral and can use all available information rationally (Frenkel, 1976, 1977, 1979; Cornell, 1997). Second, cointegration tests have been employed to examine whether the forward discount and future spot return move together (Hakkio and Rush, 1989). The first approach has been abandoned because of the non-stationary properties of future spot returns and forward discounts (Engle and Granger, 1987).

The cointegration tests yield mixed results. Some studies (Hakkio and Rush, 1989; Baillie and Bollerslev, 1989; Barnhart and Szakmary, 1991; Naka and Whitney, 1995; Hai et al., 1997) support the unbiased forward rate hypothesis. Other studies (Lai and Lai, 1991; Luintel and Paudyal, 1998) find no support for this hypothesis. Barnhart and Szakmary (1991) demonstrate that the conflicting results depend upon the econometric specification as well as upon differences in the estimation period. Engel (1996) argues that different properties of the various test statistics employed may play a role too. In order to deal with these issues, Hansen and Johansen (1999) and Rangvid and Sørensen (2002) suggest using rolling cointegration tests (we will elaborate on this method in Section 5.3). Kutan and Zhou (2003) apply this method to test for the time varying relationship between the spot and forward exchange rate for the German mark, the Japanese yen and the Swiss franc with respect to the US dollar. The merit of rolling cointegration is that it allows for potential changes in the data-generating process. In view of the changes in the Chinese foreign exchange market and the occurrence of the financial crisis, we will therefore also use rolling cointegration to investigate the Chinese foreign exchange market.

5.3 Data and Methodology

We use the daily[28] mid-price spot and (one month) forward exchange rates for the July 2005 – December 2010 period. In total, we have 1,422 daily observations. The data are derived from Datastream.

As most standard tests are not applicable when a time series has breakpoints (Kutan and Zhou, 2003), we need to investigate whether there are breakpoints in our

[28] Breuer and Wohar (1996) identify two issues that may lead to potential errors in measuring the appropriate delivery date for a spot rate: end-of period overlapping data problem and the end-of period clumping problem.

series. It appears that this indeed is the case and, therefore, we use rolling cointegration tests. In order to test whether time series have a unit root with a breakpoint, we employ the test of Zivot and Andrews (1992), while the test developed by Bai and Perron (1998, 2003) is used to find out whether there are multiple breakpoints in the series. Zivot and Andrews (1992) argue that financial crises can lead to misleading inferences when testing the unbiasedness hypothesis. We use their test to examine whether a time series has a unit root with a breakpoint. The null hypothesis in this test is that a series $\{y_t\}_1^T$ has a unit root with drift and an exogenous structural break occurs at T_B, where $1 < T_B < T$. The alternative hypothesis is that the series is stationary with a deterministic time trend and an exogenous change in the trend function at T_B. There are three alternative models to test the hypothesis: Model A allows for a one-time shift in the intercept, Model B allows for a break in the slope of the trend function, while Model C is a hybrid of A and B. The null hypotheses are:

$$\text{Model (A): } y_t = \mu + dD(T_B)_t + y_{t-1} + e_t \tag{5.1}$$

$$\text{Model (B): } y_t = \mu + y_{t-1} + (\mu_2 - \mu_1)DU_t + e_t \tag{5.2}$$

$$\text{Model (C): } y_t = \mu + y_{t-1} + dD(T_B)_t + (\mu_2 - \mu_1)DU_t + e_t \tag{5.3}$$

where $D(T_B)_t = 1$ if $t = T_B + 1$, and 0 otherwise, while $DU_t = 1$ if $t > T_B$, and 0 otherwise. The alternative hypotheses are:

$$\text{Model (A): } y_t = \mu + \beta_t + (\mu_2 - \mu_1)DU_t + e_t \tag{5.4}$$

$$\text{Model (B): } y_t = \mu + \beta_1 t + (\beta_2 - \beta_1)DT_t^* + e_t \tag{5.5}$$

$$\text{Model (C): } y_t = \mu + \beta_1 t + (\mu_2 - \mu_1)DU_t + (\beta_2 - \beta_1)DT_t^* + e_t \tag{5.6}$$

These tests can be used to examine whether the series is stationary or not with one breakpoint. However, these tests do not rule out the possibility that there are multiple breakpoints in the series. Bai and Perron (1998, 2003) evaluate which breakpoint achieves a global minimum sum of squared residuals and then sequentially examine the optimal breakpoint by solving the following recursive equation:

$$SSR(\{T_{m,t}\}) = min_{(mh \leq j \leq T-h)} [SSR(\{T_{m-1,j}\}) + SSR(j+1, t)] \quad (5.7)$$

where h is the minimum distance between each break, m is the number of breaks, T is the total number of observations, and SSR is the sum of squared residuals associated with the optimal partition containing m breaks. The procedure starts by evaluating the optimal one-break partition for subsamples and stores this breakpoint and its sum of squared residuals. Then it searches for optimal partitions with two breaks by examining which partitions can achieve a minimum sum of squared residuals, etc. Finally, the procedure evaluates which of the optimal break partitions yields a minimum sum of squared residuals. The essence of the Bai and Perron test is that the sum of squared errors can have a global minimum among all breaks in the case of multiple structural breaks. Schwartz's Bayesian Information Criterion (BIC) is used for selecting the optimal number of breakpoints. Wang (2006) demonstrates that the BIC performs consistently better for various model specifications than other information criteria, like the modified version of BIC proposed by Liu et al. (1997) and the Hannan and Quinn (1979) criterion.

The breakpoint tests of Bai and Perron (1998, 2003) can establish whether there are any breakpoints in a relationship. However, these tests cannot reveal whether the relationship becomes stronger or weaker. We use rolling cointegration to establish the time-varying relationship between the future spot return and forward discount rate of the Renminbi vis-à-vis the US dollar. Cointegration between $(S_{t+1}-S_t)$ and (F_t-S_t) is a necessary (but not sufficient) condition for the FRUH to hold. If $(S_{t+1}-S_t)$ and (F_t-S_t) are not cointegrated, they tend to deviate apart without any boundaries so that (F_t-S_t) has little predictive power regarding the movement of $(S_{t+1}-S_t)$. This is inconsistent with the unbiased forward rate hypothesis.

With cointegration, a time series is integrated of order d — denoted as $I(d)$ — if the series can become stationary after differencing d times. An $I(0)$ series is stationary, whereas an $I(1)$ series contains a unit root and is non-stationary. When the future spot return $(S_{t+1}-S_t)$ and the forward discount (F_t-S_t) are both $I(1)$, the linear combination is generally also $I(1)$. However, if there exist parameters a and b such that Z is stationary, then $(S_{t+1}-S_t)$ and (F_t-S_t) are cointegrated. The relationship between the two is as follows:

$$Z_t = (S_{t+1} - S_t) - a - b\,(F_t - S_t) \tag{5.8}$$

where Z_t represents the equilibrium error. For cointegration tests, two methods are widely used, namely the Engle and Granger (1987) test and the Johansen (1991) test. The Johansen test permits more than one cointegration relationship. As such, it is more generally applicable than the Engle–Granger test, which is based on the (augmented) Dickey–Fuller test for unit roots in the residuals from a single (estimated) cointegration relationship.

The Johansen test is based on the VAR model estimation. Consider the VAR (p) model for the $k \times 1$ vector Y_t

$$Y_t = \Pi_1 Y_{t-1} + \ldots + \Pi_p Y_{t-p} + \mu_t t = 1, \ldots, T \tag{5.9}$$

where $\mu_t \sim$ IN (0, $\sum$). Since the level of time series Y_t might be non-stationary, Equation (5.3) needs to be transformed into a dynamic form, a vector error correction model (VECM)

$$\Delta Y_t = \Pi_1 Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \ldots + \Gamma_{p-1} \Delta Y_{t-p+1} + \mu_t \; t = 1, \ldots, T \tag{5.10}$$

where $\Pi = \Pi_1 + \ldots + \Pi_p - I_n$ and $\Gamma_k = -\sum_{j=k+1}^{p} \Pi_j$, k=1, p-1. If Y_t contains non-stationary I time series components, Y_{t-1} has to be stationary in order to get a stationary error term μ_t. Therefore, Y_{t-1} must contain $r<k$ cointegration relations. If the VAR(p) process has unit roots then Π has a reduced rank $r<k$. Effectively, testing for cointegration is equivalent to assessing the rank of the matrix. If $r=k$, then time series in Y are stationary, if the rank of the matrix is zero then there are no cointegration relationships. If $0<r<k$ Y_t is I with r linearly independent cointegrating vectors and $k - r$ non-stationary vectors.

In order to determine the number of cointegrating vectors, we first test H_0: $r_0=0$ against the alternative H_1: $r_0 > 0$. If this null is not rejected, we conclude that there are no cointegrating vectors among the k variables in Y_t. If H_0: $r_0=0$ is rejected, then there is at least one cointegrating vector. In this case we should test H_0: $r_0<=1$ against H_1:

$r_0 > 1$. If this null is not rejected then there is only one cointegrating vector. If the null is rejected then there are at least two cointegrating vectors. The tests are performed on H_0: $r_0 <= 2$ and so on, until the null hypothesis is not rejected. Cointegration is only one of the two necessary conditions for the unbiased forward rate hypothesis to hold. If the cointegration holds, we have to further test the second condition which requires that $a=0$ and $b=1$ in equation (5.8). If this condition does not hold, (F_t-S_t) is not an unbiased predictor of $(S_{t+1}-S_t)$, even if the two move together in time. Hence, a test of the FRUH also involves testing for the restrictions on the parameters, notably that $b=1$. We also perform this test on the rolling cointegration vector.

5.4 Empirical Results

In this section, we report the results of our analysis of the Renminbi – US dollar exchange rate. The results of the Zivot and Andrews (1992) unit root tests are shown in Table 5.1. The test statistics in all three models clearly reject the null hypothesis. However, on the basis of these tests, only one structural breakpoint can be identified. In order to test whether there are multiple breakpoints, we use the tests of Bai and Perron (1998, 2003) which sequentially search for endogenous multiple breakpoints based on minimizing the sum of squared residuals in all sub-samples. Table 5.2 reports the breakpoints identified by the Bai and Perron tests. From the minimum BIC criterion, we derive that there are four breakpoints in the series: August 2, 2006; August 9, 2007; June 26, 2008; and March 9, 2010.

According to Annual Balance of Payment Report for China, the Renminbi-Pound interbank trade was launched in the China Foreign Exchange Trading System on August 1, 2006, which may explain the first break point. On August 17, 2007, the State Administration of Foreign Exchange announced that the Renminbi foreign exchange swap transaction would soon start, which was around the second break point. After the Renminbi foreign exchange swap transaction was launched at the end of 2007, there were neither announcements nor actions from any authorities related to the exchange market until February 2010. However, as pointed out by Ma and McCauley (2011), in mid-2008 the financial crisis interrupted the appreciation of the Renminbi. President Zhou of the PBOC described the policy reversion to closely link the Renminbi to the dollar during the global financial crisis as a “special measure”

(Financial Times, 8 March 2010). Therefore, we interpret the breakpoint in Summer 2008 as the impact of the global financial crisis on the Chinese foreign exchange market.

As suggested by one of the referees, we also examine the variation of the interest rate differential between China and the United States in this particular period. Flood and Rose (2002) suggest that interest rate hikes typically accompanied defenses of fixed exchange rate regimes in crisis periods. Under this view, more volatility in interest rates at home (compared to foreign interest rates) may help to observe the FRUH more often: Investors demand higher interest rates on currencies expected to fall in value (Sarno, 2005). We notice that in July 2008, the interest rate differential between China and the United States shifts from negative to positive, suggesting that investors no longer expect the Renminbi to appreciate in line with the objective to peg the Chinese currency.

In February 2010, the authorities decided to raise the maximum position of exchange settlement and exchange sales for nationwide banks. Meanwhile, the positions of exchange settlement and sales for small banks also were allowed to increase. These developments may be held responsible for the fourth breakpoint in March 2010.

Table 5.1 Zivot-Andrews unit root tests

	A	B	C
St+1 - St	-7.7193***	-6.1074***	-7.8672***
	[June 17, 2008]	[Oct 9, 2007]	[June 17, 2008]
Ft - St	-7.3935***	-5.0818***	-7.5966**
	[April 18, 2008]	[Nov 7, 2005]	[April 18, 2008]

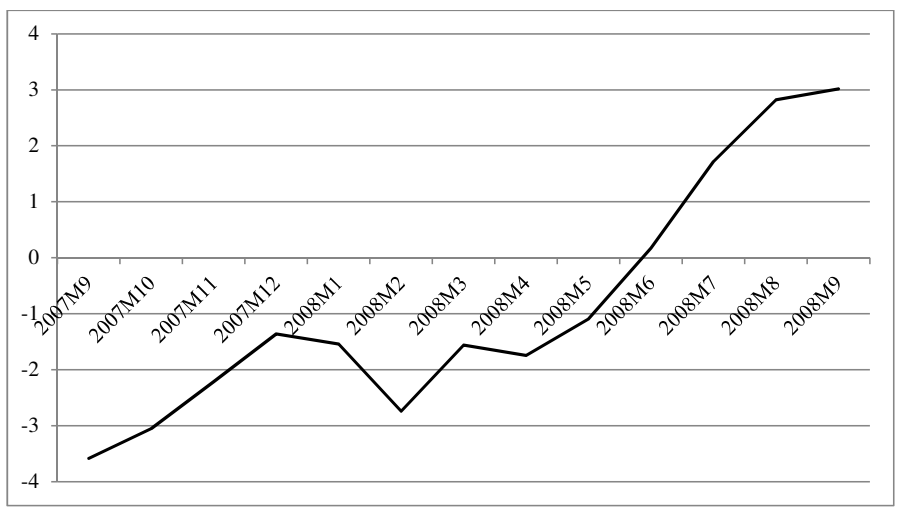
Note: Zivot and Andrews (1992) unit root tests with an endogenously determined breakpoint. A, B, C denote model types and correspond to the three models in the main text. The 1%, 5% and 10% critical values are -5.34/-4.80/-4.58, -4.93/-4.42/-4.11 and -5.57/-5.08/-4.82 for models A, B and C, respectively. The numbers in parentheses are the estimated structural break dates. *** Rejection of the null hypothesis at the 1% level. The null hypothesis is that a series has a unit root with drift and an exogenous structural break.

Table 5.2 Bai and Perron test results

Numbers	Break Times	BIC
M = 0		-5983.119
M = 1	Aug 2, 2006	-6104.114
M = 2	Aug 9, 2007 Jun 26, 2008	-6383.262
M = 3	Aug 9, 2007 Jun 26, 2008 Mar 9, 2010	-6504.174
M = 4	Aug 2, 2006 Aug 9, 2007 Jun 26, 2008 Mar 9, 2010	-6610.446
M = 5	Aug 2, 2006 Aug 9, 2007 Jun 26, 2008 Apr 21, 2009 Mar 9, 2010	-6589.463

Note: Bai and Perron (1998, 2003) multiple breakpoints tests. The minimum Bayesian Information Criterion (BIC) criterion is used for selecting the best break points.

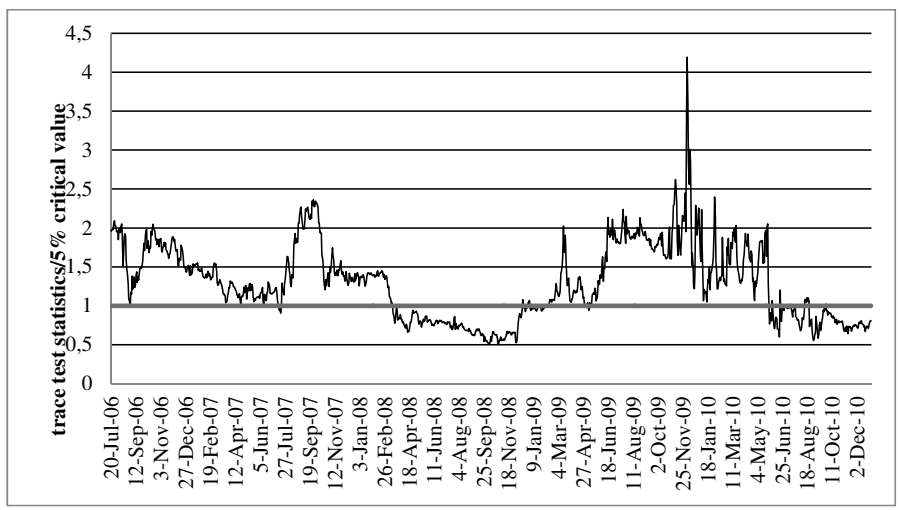
Figure 5.4 The real interest rate differential between China and the United States



Note: Data source: IFS. The interest rate in China is the annual deposit rate. The interest rate in the United States is the one-year US Treasury rate. The real interest rate equals the nominal interest rate minus consumer prices.

As the Bai and Perron tests suggest multiple breakpoints in the relationship between the future spot return and the forward discount, we will use rolling cointegration to test the relative strength of the cointegration relation. We calculate the Johansen trace test statistics for a rolling, fixed-length window of 261 observations (i.e. the number of trading days in one calendar year). The Schwartz information criterion is used to determine the optimal lag length of 1. The null hypothesis of $r=0$ against $r>0$ is tested. The test statistics are calculated for a rolling window by adding one observation to the end and removing the first observation. That is, starting with observations [1–261], we calculate the first trace test statistics. Then, we calculate the trace tests for observations [2–262], [3–263], etc. The trace test statistics are divided by their 5% critical values and shown in Figure 5.5. A value of the scaled test statistic above one means that the corresponding null hypothesis can be rejected at the 5% level for that period.

Figure 5.5 Rolling cointegration test (r=0)



Note: The figure shows rolling cointegration tests scaled by their critical values (at 95 percent confidence level) from VAR models. A level above 1 suggests rejection of the hypothesis of respectively $r \leq 0$, that is, rejection of no cointegration. The r signifies the rank of the matrix Π.

Rejection of the null hypothesis of no cointegration suggests that the spot future return and forward discount are cointegrated. The results as shown in Figure 5.5

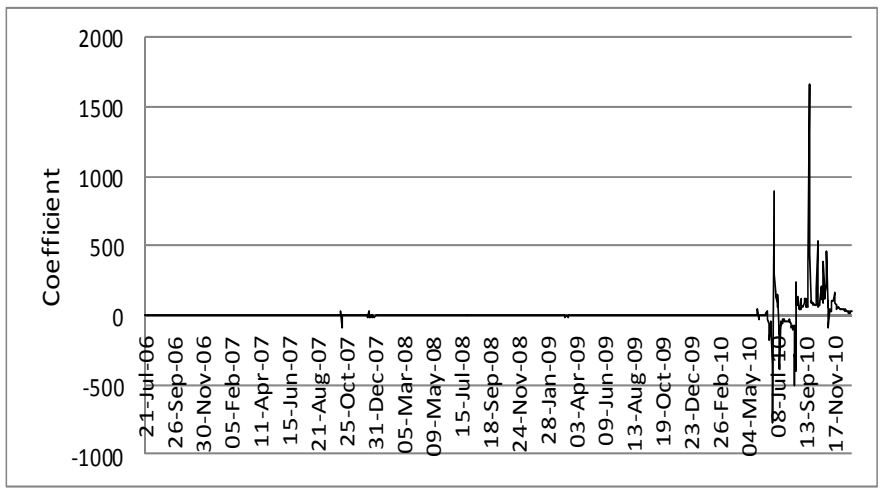
suggest a time-varying link between the future spot return and the forward discount of the Renminbi vis-à-vis the US dollar. The existence of a cointegration relationship between the future spot return and the one–month forward discount rate before March 2008 cannot be rejected. The breakpoint of March 2008 is close to the breakpoint in June 2008 as identified by the Bai and Perron tests. As shown in Figure 5.1, since June 2008, the spot rate stopped appreciating against the dollar. The Spring 2008 breakpoint can be regarded as the moment at which the Chinese foreign exchange market was hit by the global financial crisis. Figure 5.5 suggests that the future spot return and forward discount are not cointegrated between March 2008 and February 2009. However, the cointegration relationship gained ground again after February 2009 until about June 2010. After June 2010, the test statistics for cointegration are around the 5% critical values. As mentioned in Section 5.2, the Chinese government continued its exchange rate policy of gradual appreciation in June 2010. After this period, cointegration only sporadically occurs.

In all, we establish that since the change in China´s exchange rate regime in July 2005, four different sub-periods can be identified on the basis of our cointegration analysis regarding the future spot return and the forward discount rate. First, there is cointegration before the financial crisis (July 2005 - Spring 2008). Second, there is no cointegration in the early stages of the crisis (Spring 2008-Spring 2009), i.e. when the financial crisis spread from the US to the rest of the world. Arguably, the cointegration relationship is weak because the trend of the Renminbi with respect to the dollar was very hard to predict. Third, there again is a cointegration relationship in the later stage of the global crisis (Spring 2009-Spring 2010). In this period the spot exchange rate is virtually constant. Apparently, when the financial crisis spread, the expectations from market participants became more uniform, namely that the Renminbi-dollar rate will stop appreciating for a while, until the impact of the crisis is clear. It was easier for market participants to anticipate the exchange rate in the later stages of the crisis. Fourth, there is no cointegration after the Chinese government continued its policy of gradual appreciation (Summer 2010 – Winter 2010).

As explained in Section 5.2, cointegration is a necessary but not a sufficient condition for the FRUH. For $(F_t\text{-}S_t)$ to be an unbiased predictor of $(S_{t+1}\text{-}S_t)$, the cointegration vector coefficient should also be unity in equation (5.8). For those periods for which we find cointegration, we test the rolling cointegration coefficients

of (S_{t+1}-S_t) and (F_t-S_t). If -*b* in equation (5.8) is -1 when there is cointegration, the unbiased hypothesis holds. If the coefficients –*b* are far from -1, the unbiased hypothesis does not hold even when there is cointegration. Figure 5.6 shows the time-varying cointegration coefficients. It shows that hardly fluctuated until summer 2010. However, they fluctuate vehemently in the second half of 2010. Therefore, we reject the unbiased forward rate hypothesis for this period.

Figure 5.6 Rolling cointegration coefficients



Note: The figure shows rolling cointegration coefficients, which is the coefficient –b in (5.8). If the coefficient is -1, the unbiased hypothesis holds.

Figures 5.A in the Appendix show the rolling cointegration coefficient for the five sub-periods identified on the basis of the Bai and Perron tests and the rolling cointegration tests. The first breakpoint identified in the Bai and Perron test is within one month from July 21, 2005. However, the rolling cointegration test in this period does not display a significant difference before and after this point. Therefore, we will set the end of the first sub-period in August 2007, which is the second breakpoint identified in the Bai and Perron test. The second sub-period lasts to March 2008 when the cointegration relation breaks down. This is around the third breakpoint identified by the Bai and Perron test. The third sub-period lasts until February 2009, when the cointegration relation recovers. The fourth sub-period lasts to March 2010, which is the fourth breakpoint in the Bai and Perron test. After March 2010 is the fifth period.

Figure 5.A.1 and 5.A.2 show that the coefficients of the cointegration vector are far from -1, so the unbiasedness hypothesis does not hold in the first and second sub-periods. Figure 5.A.3 and 5.A.4 show that sometimes the coefficient of the cointegration vector is -1 in the third and fourth sub-periods. However, as the cointegration relationship in the third period is rejected, so is the FRUH. In contrast, the unbiasedness hypothesis holds in the fourth sub-period, albeit that the evidence is not always very strong. Figure 5.A.5 shows that in the fifth sub-period b deviates from unity. On the whole, the cointegration coefficients $-b$ in (5.8) are less than 0 in the crisis period and greater than 0 in the non-crisis period. This result confirms the empirical evidence that the slope coefficient b is significantly less than unity and mostly negative in non-crisis periods. In Table 5.3, we summarize our results for the five sub-periods.

Table 5.3 Summary of results

Period	Cointegration Test	Unity Cointegration Vector Coefficient
July 2005 – Autumn 2007	√	×
Autumn 2007 – Spring 2008	√	×
Spring 2008 – Spring 2009	×	——
Spring 2009 – Spring 2010	√	√×
Spring 2010 – End 2010	×	——

Note: √ means hold, × means does not hold, √× means sometimes hold, sometimes does not hold, and — means that cointegration does not hold; we do not test the cointegration vector coefficient.

5.5 Conclusion

We examine the relationship between the future spot return and the forward discount rate in China by employing breakpoint tests and rolling cointegration. We complement Frankel and Poonawala (2010) and examine the impact of the global financial crisis on the relationship between the future spot return and the forward discount rate in China. We find that the cointegration relationship between the future spot return and the forward discount rate is time-varying. This dynamic relationship may reflect divergence in the market expectations regarding the exchange rate of the Renminbi.

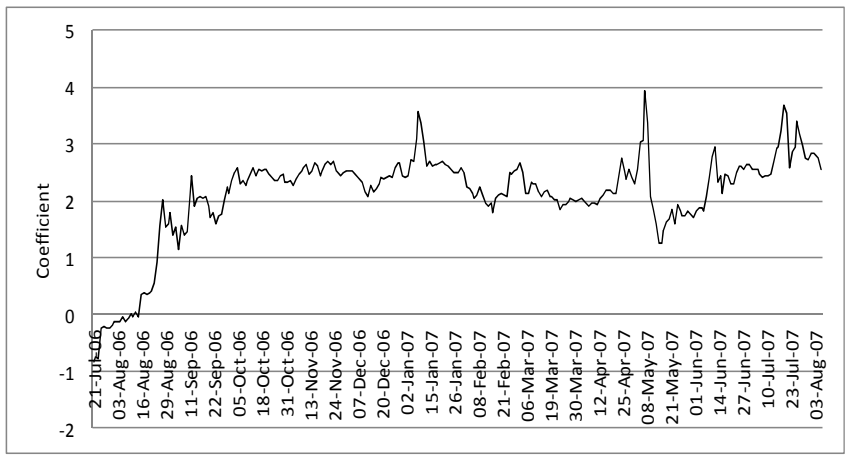
We conclude that cointegration between future spot returns and forward discount rates in China broke down in the early stages of the financial crisis. However,

cointegration cannot be rejected for later stages of the financial crisis. The global financial crisis had considerable impact on the forward discount bias and upheld the forward rate unbiasedness hypothesis by reverting the negative sign into positive. This result is in line with the findings from Jeon and Seo (2003) who conclude that market efficiency appears to have become weaker immediately after a crisis, but that it recovers quickly. We find that the unbiased hypothesis does only hold in Spring 2009 when both the spot and forward exchange rate are almost invariant. The result is congruent with previous studies that conclude that the unbiased hypothesis tends to hold in times of crisis (Bai and Mollick, 2010).

Appendix

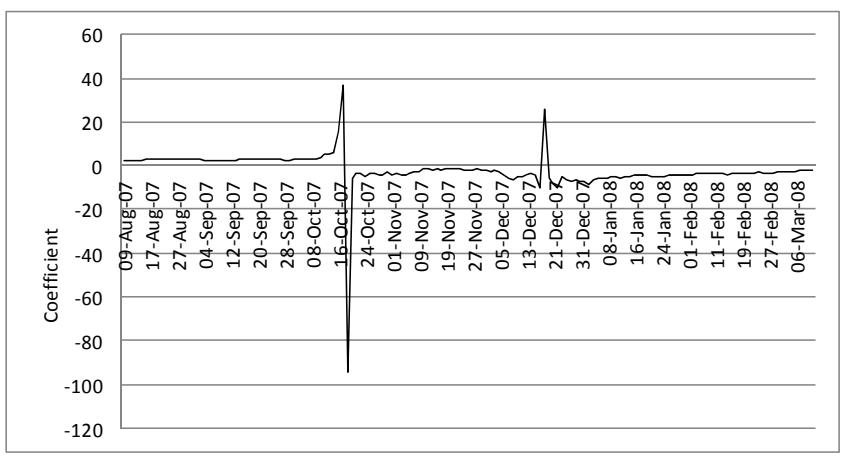
5.A Rolling cointegration coefficients for Sub-periods

5.A.1 Rolling cointegration coefficients (Sub-period 1)



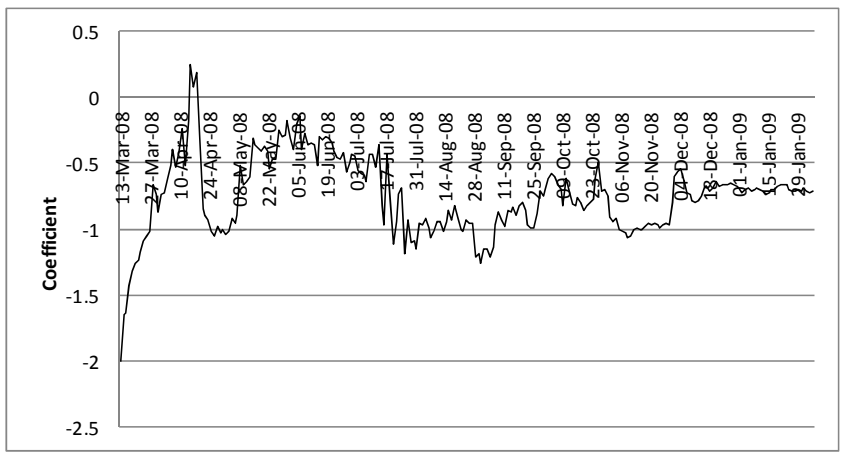
Note: The figure shows rolling cointegration coefficients, which is the coefficient –b in (5.8). If the coefficient is -1, the unbiased hypothesis holds.

5.A.2 Rolling cointegration coefficients (Sub-period 2)



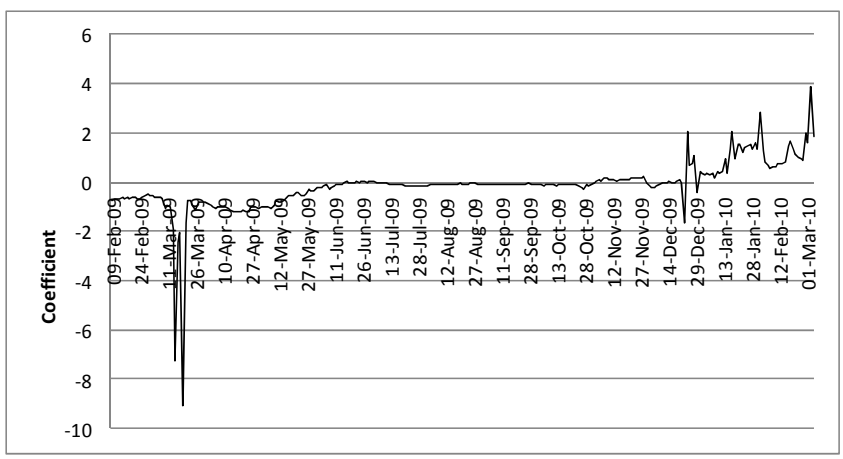
Note: The figure shows rolling cointegration coefficients, which is the coefficient –b in (5.8). If the coefficient is -1, the unbiased hypothesis holds.

5.A.3 Rolling cointegration coefficients (Sub-period 3)



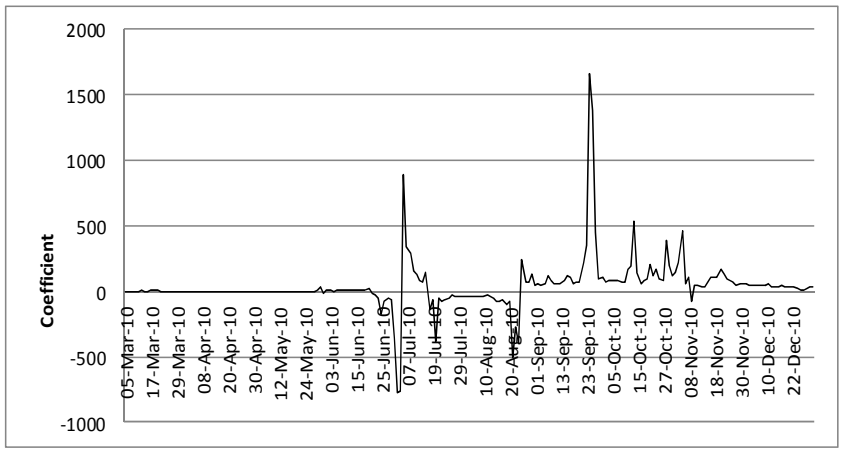
Note: The figure shows rolling cointegration coefficients, which is the coefficient –b in (5.8). If the coefficient is -1, the unbiased hypothesis holds.

5.A.4 Rolling cointegration coefficients (Sub-period 4)



Note: The figure shows rolling cointegration coefficients, which is the coefficient –b in (5.8). If the coefficient is -1, the unbiased hypothesis holds.

5.A.5 Rolling cointegration coefficients (Sub-period 5)



Note: The figure shows rolling cointegration coefficients, which is the coefficient –b in (5.8). If the coefficient is -1, the unbiased hypothesis holds.

Chapter 6

Conclusions and Policy Implications

The linkages between international capital flows, currency crises and exchange rate regimes are relevant for global financial stability in an increasingly integrated world. This dissertation contributes to the literature both methodologically and empirically. The research questions addressed in this dissertation are:

(1) Are Chinese hot money flows related to developments in the real estate and the stock markets, the interest rate differential vis-à-vis the US, the expected exchange rate appreciation, and the Chicago Board Options Exchange Market Volatility Index (VIX)? Does their effect depend on structural reforms and new regulations as well as the recent financial crisis? Are results affected by the choice of a particular measure for hot money?

(2) Which factors determine whether a sudden stop is followed by a currency crisis or not? Does the exchange rate regime play a role here?

(3) Are leading indicators of currency crises different in different exchange rate regimes? If so, which indicators are useful for different exchange rate regimes?

(4) What is the relationship between the Renminbi future spot return and the forward discount rate? Does the unbiased forward exchange rate hypothesis hold in China? What is the influence of the recent financial crisis on this relationship?

Sections 6.1-6.4 consecutively will answer these four questions.

6.1 The dynamics of hot money in China

We study the empirical determinants of China's hot money using Autoregressive Distributed Lag (ARDL) models from Pesaran et al. (1999). We use four alternative measures of hot money in the period January 2000 to December 2012. Furthermore, we examine the impact of the qualified foreign institutional investors (QFII) regulation of July 2003, the exchange rate reform of July 2005, the new regulation of foreign investments in the real estate market in July 2006, and the global financial crisis. Our explanatory variables include global macroeconomic factors and domestic

macroeconomic factors that are commonly considered in the literature. The global factors are the interest rate differential between China and the United States and market volatility as proxied by the Chicago Board Options Exchange Market Volatility Index (VIX). The domestic factors consist of the expected exchange rate appreciation and proxies for developments at the stock and real estate markets. Our findings are largely in accordance with the results of previous studies: an expected appreciation significantly encourages hot money flows into China. Our results also suggest that the significance of the VIX, the stock market index and the real estate climate index depend on the way in which we measure hot money. Specifically, our first measure of hot money (found by subtracting the trade surplus and net foreign direct investment (FDI) from the change in official foreign reserves) is significantly affected by the VIX, while our second and third measures of hot money are significantly affected by the stock market index and the real estate climate index. The second measure uses adjusted foreign reserves instead of official foreign reserves. The third measure adds a rough estimation of hot money in trade invoicing. Thus, the relevance of the factors depends on the choice of a specific hot money measure. The alternative measures offer consistent results regarding the significance of QFII and of the exchange rate reform: they are not effective. But the regulation of foreign investment in the real estate market and the financial crisis has a significant effect.

It might be worthwhile for policy makers to entertain the idea that the factors driving hot money flows in China depend on the measures of hot money, however, the expected exchange rate is a robust driver. Thus a stable exchange rate policy is essential in reducing Chinese hot money flows.

6.2 Sudden stops and currency crashes

The second question addressed in this dissertation is why sudden stops are accompanied by currency crashes in some countries but not in others. We use a sample of 85 economies in the period 1980-2010. In line with theoretical models (Krugman, 1979; Obstfeld, 1994; McKinnon and Pill, 1999; Hausmann et al., 1999; Aghion et al., 2001), the explanatory variables we consider include trade to GDP, exports to GDP, current account to GDP, financial openness, inflation rate, claims on central government as a share of GDP, the ratio of M2 to GDP, domestic credit

provided by the banking sector as a percentage of GDP, and total reserves in months of imports. We rely on an event study approach and probit regressions. Both approaches suggest that low trade openness, shallow financial markets, and current account imbalances raise the likelihood of sudden stops with currency crashes. Furthermore, the sub sample regressions show that the exchange rate regime plays a significant role. More specifically, the current account plays a crucial role in the three types of exchange rate regime that we distinguish (i.e. hard pegs, other pegs and intermediate regimes). A surplus current account decreases the probability of having sudden stops with currency crashes. Higher budget deficits significantly increase the likelihood of sudden stops with currency crashes in the case of hard pegs. Higher trade openness significantly decreases the likelihood of sudden stops with currency crashes in both hard and other pegs. A deeper financial system significantly decreases the probability of sudden stops with currency crashes in both other pegs and intermediate regimes.

Our results indicate that sudden stops need not automatically translate into currency crashes. In order to minimize this risk, an open trade sector, a balanced external sector and a deeper financial market is required. We suggest ways for maintaining financial stability under alternative exchange rate regimes. Economies with a hard peg should aim for balanced government budgets and open up their trade sector. Economies with other pegs should develop their financial sector and open up their trade sector, while economies with an intermediate regime should develop their financial sector.

6.3 Leading indicators of currency crises

We identify which variables indicate that a country is vulnerable to a currency crisis in alternative exchange rate regimes. The indicators are evaluated on the basis of their in-sample performance using both probit model and the threshold model of Kaminsky et al. (1998) for 88 economies in the period 1980-2010. The variables we incorporate are: external indicators (real exchange rate, growth of exports, foreign reserves, the US interest rate, external debt and short-term foreign debt), real sector indicators (GDP growth, unemployment and the government budget deficit), credibility indicators (inflation and interest rate differential), monetary policy

indicators (domestic credit and M2 growth), and banking sector vulnerability (lending to deposit rate). We find several interesting differences across exchange rate regimes. In particular, our results suggest that in fixed exchange regimes a marked appreciation of the real exchange rate (relative to trend) and a substantial loss of foreign exchange reserves are good indicators of vulnerability. Under floating exchange rate regimes, monetary policy and credibility indicators, such as domestic credit growth and inflation, are the best leading indicators of currency crises. Both credibility and external economic indicators have predictive power in intermediate exchange rate regimes.

On the basis of our analysis, we speculate that the single early warning model will be displaced by multiple models in the world of mobile capital and more deregulated financial markets. It is useful to explore alternative early warning systems for different exchange rate regimes.

6.4 The relationship between the Renminbi future spot return and the forward discount rate

We investigate the unbiased forward exchange rate hypothesis (according to which, given conditions of rational expectations and risk neutrality, the forward exchange rate is an unbiased predictor of the future spot exchange rate) in the presence of unknown structural breaks by applying rolling cointegration tests. We use the daily Renminbi - US dollar exchange rate from 21 July 2005 to 31 December 2010 to test the relationship between the future spot return and the forward discount rate. This is the period after the exchange rate policy reform in 2005. We first investigate whether there are breakpoints in our series since most standard tests are not applicable when a time series has breakpoints. The timing of each break is selected using the tests suggested by Zivot and Andrews (1992) and Bai and Perron (1998, 2003). The selected structural breaks coincide with the launch of the Renminbi-Pound sterling interbank market, the announcement of the Renminbi foreign exchange swap transaction, the start of the global financial crisis and the decision of the Chinese central bank to raise the maximum position of exchange settlement and exchange sales for nationwide banks. Furthermore, we apply rolling

cointegration tests for the future spot return and the forward discount rate. Four different sub-periods can be identified on the basis of our cointegration analysis. First, there is cointegration before the financial crisis (July 2005–Spring 2008). Second, there is no cointegration in the early stages of the crisis (Spring 2008–Spring 2009). Arguably, the trend of the Renminbi with respect to the dollar was very hard to predict. Third, there again is a cointegration relationship in the later stage of the global crisis (Spring 2009–Spring 2010). In this period, the spot exchange rate is virtually constant. Apparently, when the financial crisis spread, market participants expected that the Renminbi - US dollar exchange rate would stop appreciating. Fourth, there is no cointegration after the Chinese government continued its policy of gradual appreciation (Summer 2010–Winter 2010). Moreover, we find that the unbiased forward exchange rate hypothesis does hold in Spring 2009, when the Chinese authorities returned to peg the Renminbi to the US dollar to overcome the turmoil of the global financial crisis. We conclude that cointegration between future spot returns and forward discount rates in China broke down in the early stages of the financial crisis. However, cointegration cannot be rejected for later stages of the financial crisis.

Our results suggest that in the early period of the crisis, market efficiency appears to become weaker immediately, but that it recovers quickly. In the case of China, the market efficiency tightly relates to the transformation of exchange rate regimes. These results suggest that the forward market for the Renminbi is inefficient.

6.5 Limitations

This dissertation has some limitations.

In Chapter 2, neither the direct method nor the indirect method can is able to record hot money flows precisely. We give rough estimations of Chinese hot money flows.

In chapter 3, additional explanatory variables can be considered. Examples of some additional variables are political and institutional indicators (Acemoglu et al., 2003). We leave this for future research.

In chapter 4, , we focus on currency crises. Other types of crisis, particularly bank and debt crises, are also very frequent. Therefore, we can expand our idea to other

types of crisis in order to develop a full view of financial crises. Especially, the suggestion to construct different indicators for alternative exchange rate regimes can be applied to debt and bank crises. Furthermore, one line of future research includes analyzing the recent currency crisis which has several new characteristic. What accounts for diversity is food for future research. For example, the crisis took place in both advanced and less advanced economies after 2008. However, the mechanism of crisis in advanced and less advanced economies could be different. This is a line of research that can also be expanded.

In chapter 5, we use Bai and Perron (2003) to determinate break points. However, the limitation of this method is that it precludes integrated variables with an autoregressive unit roots.

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Samenvatting

In een steeds meer geïntegreerde wereld is de koppeling tussen internationale kapitaalstromen, valutacrises en wisselkoersregimes van belang voor de mondiale financiële stabiliteit. Dit proefschrift draagt, zowel methodologisch als empirisch, bij aan de literatuur. De onderzoeksvragen die in dit proefschrift aan bod komen zijn:

(1) Is Chinees vluchtkapitaal ("hot money") gerelateerd aan ontwikkelingen in de vastgoed- en de aandelenmarkten, het renteverschil ten opzichte van de VS, de verwachte appreciatie van de wisselkoers en de Chicago Board Options Exchange Market Volatility Index (VIX)? Hangen deze relaties af van structurele hervormingen en nieuwe regelgeving en van de recente financiële crisis? Worden de resultaten beïnvloed door de keuze van een bepaalde maatstaf van vluchtkapitaal?

(2) Welke factoren bepalen of een plotselinge ingrijpende vermindering van internationale kapitaalstromen wordt gevolgd door een valutacrisis of niet? Speelt de wisselkoers – en met name het wisselkoersregime – hierbij een rol?

(3) Zijn leidende indicatoren van valutacrises verschillend in verschillende wisselkoersstelsels? Zo ja, welke indicatoren zijn bruikbaar bij verschillende wisselkoersstelsels?

(4) Wat is de relatie tussen het toekomstige contante koers rendement ("future spot return") van de renminbi en het agio op de termijnkoers ("forward discount rate")? Geldt de "unbiased forward rate" hypothese in China? Wat is de invloed van de recente financiële crisis op deze relatie?

We geven achtereenvolgens antwoord op deze vier vragen.

We bestuderen de empirische determinanten van China's vluchtkapitaal met behulp van "Autoregressieve Distributed Lag" (ARDL) modellen zoals ontwikkeld door Pesaran et al. (1999). We gebruiken vier alternatieve maatstaven van vluchtkapitaal in de periode van januari 2000 tot december 2012. Verder onderzoeken we de invloed van de gekwalificeerde buitenlandse institutionele beleggers (QFII) regeling van juli 2003, de wisselkoershervorming van juli 2005, de nieuwe verordening voor buitenlandse investeringen in onroerend goed van juli 2006 en de wereldwijde financiële crisis. Onze verklarende variabelen zijn wereldwijde macro-economische factoren en binnenlandse macro-economische factoren die

gewoonlijk ook in de literatuur worden beschouwd. De mondiale factoren zijn het renteverschil tussen China en de Verenigde Staten en de marktvolatiliteit zoals weergegeven door de Chicago Board Options Exchange Market Volatility Index (VIX). De binnenlandse factoren bestaan uit de verwachte appreciatie van de wisselkoers en maatstaven voor ontwikkelingen op de aandelen- en vastgoedmarkten. Onze bevindingen zijn grotendeels in overeenstemming met de resultaten van eerdere studies: een verwachte waardestijging stimuleert vluchtkapitaal naar China. Onze resultaten suggereren ook dat de significantie van de VIX, de beursindex en de onroerend goed klimaat-index afhankelijk is van de wijze waarop we vluchtkapitaal meten. Onze eerste maatstaf voor vluchtkapitaal (gevonden door het handelsoverschot en de netto buitenlandse directe investeringen (FDI) af te trekken van de verandering in de officiële externe reserves) wordt significant beïnvloed door de VIX, terwijl onze tweede en derde maatstaven van vluchtkapitaal significant worden beïnvloed door de beursindex en de onroerend goed klimaat-index. De tweede maatstaf maakt gebruik van aangepaste buitenlandse reserves in plaats van de officiële externe reserves. De derde maatstaf voegt een ruwe schatting van vluchtkapitaal in de handelsfacturering toe. De relevantie van de factoren hangt dus af van de keuze voor een specifieke maatstaf voor vluchtkapitaal. De alternatieve maatstaven bieden consistente resultaten met betrekking tot de betekenis van QFII en de wisselkoershervorming: ze zijn niet effectief. We vinden dat de regelgeving ten aanzien van buitenlandse investeringen in onroerend goed en de financiële crisis een significante invloed hebben op het vluchtkapitaal, maar de resultaten zijn onafhankelijk van de keuze voor een bepaalde maatstaf.

De tweede vraag die in dit proefschrift aan bod komt is waarom plotselinge substantiële verminderingen van internationale kapitaalstromen (zogenaamde ‘sudden stops’) worden vergezeld van valutacrises in sommige landen, maar juist niet in andere landen. We maken hiertoe gebruik van een steekproef van 85 landen in de periode 1980-2010. In overeenstemming met theoretische modellen beschouwen wij als verklarende variabelen onder meer de handel als aandeel van het BNP, de lopende rekening, financiële openheid, inflatie, vorderingen op de centrale overheid, de verhouding van M2, de binnenlandse kredietverlening door het bankwezen en de totale reserves gerekend in maanden import. De variabelen worden waar nodig

geschaald in relatie tot de omvang van het BNP. Wij baseren ons op een “event study” benadering en op probit regressies. Beide benaderingen suggereren dat geringe openheid voor handel, ondiepe financiële markten en onevenwichtigheid op de lopende rekening de kans op plotselinge stops met valutacrashes verhoogt. Bovendien blijkt uit deelregressies dat het wisselkoersregime een belangrijke rol speelt. Meer specifiek speelt de lopende rekening een cruciale rol in de drie soorten wisselkoersregimes die we onderscheiden (vaste wisselkoers, andere koppelingen en tussenliggende regimes): Een overschot op de lopende rekening vermindert de kans op plotselinge stops met valutacrashes. In een vast wisselkoers regime verhoogt een stijging van het begrotingstekort de kans op plotselinge stops met valutacrashes. Meer openheid in de handel vermindert de kans op plotselinge stops met valutacrashes bij zowel vaste wisselkoersen als in andere regimes. Een diepere financiële ontwikkeling vermindert de kans op plotselinge stops met valutacrashes in tussenliggende regimes.

De bovengenoemde verschillen suggereren manieren voor de autoriteiten om financiële stabiliteit onder alternatieve wisselkoersstelsels te behouden. Economieën met een vast wisselkoersregime zouden in dat geval moeten streven naar evenwichtige begrotingen en openstelling van hun handelssector. Landen met andere koppelingen zouden hun financiële sector moeten ontwikkelen en hun handelssector openstellen, terwijl economieën met een tussenliggend regime hun financiële sector moeten ontwikkelen.

Als antwoord op de derde vraag gaan we voor verschillende wisselkoersstelsels na welke variabelen erop wijzen dat een land kwetsbaar is voor een valutacrisis. De indicatoren worden voor 88 economieën in de periode 1980-2010 geëvalueerd op basis van hun “in-sample” prestaties met zowel probit modellen als de benadering van Kaminsky et al. (1998). Wij gebruiken de volgende variabelen: externe indicatoren (reële wisselkoers, de groei van de export, de buitenlandse reserves, de Amerikaanse rente, de buitenlandse schuld en de kortlopende buitenlandse schuld), reële sector indicatoren (BNP-groei, de werkloosheid en het tekort op de overheidsbegroting), geloofwaardigheid indicatoren (inflatie en renteverschil), indicatoren voor monetair beleid (binnenlands krediet en groei van M2), en de kwetsbaarheid van de banksector (kredietverlening versus depositorente). We vinden

een aantal interessante verschillen tussen de onderscheiden wisselkoersstelsels. In het bijzonder suggereren onze resultaten dat bij vaste wisselkoersregimes een duidelijke appreciatie van de reële wisselkoers (ten opzichte van de trend) en een aanzienlijk verlies van de deviezenreserves goede indicatoren van kwetsbaarheid zijn. In zwevende wisselkoersregimes zijn het monetaire beleid en geloofwaardigheidsindicatoren, zoals de binnenlandse kredietgroei en inflatie, de beste indicatoren van valutacrises. Zowel geloofwaardigheids- als externe economische indicatoren hebben voorspellende kracht in tussenliggende wisselkoersstelsels.

We onderzoeken de vierde onderzoeksvraag over de "unbiased forward rate" hypothese (volgens welke, gegeven voorwaarden van rationele verwachtingen en risico-neutraliteit, de termijnkoers een zuivere voorspeller van de toekomstige contante wisselkoers is) door voortschrijdende coïntegratie testen ("rolling cointegration") toe te passen. Om de relatie tussen het toekomstige koersrendement en het agio op de termijnkoers te testen gebruiken we de dagelijkse renminbi - US dollarkoers van 21 juli 2005 tot 31 december 2010. Dit is de periode na de hervorming van het Chinese wisselkoersregime in 2005. We onderzoeken eerst of er breekpunten zijn onze reeks, aangezien de meeste standaardtesten niet van toepassing zijn wanneer een tijdreeks breekpunten heeft. De datering van elke breuk wordt geselecteerd met testen zoals ontwikkeld door Zivot en Andrews (1992) en Bai en Perron (1998, 2003). De geselecteerde structurele breuken vallen samen met de lancering van de renminbi – Britse pond interbancaire markt, de toestemming voor renminbi valutaswap transacties, het begin van de wereldwijde financiële crisis en de beslissing van de Chinese centrale bank om de maximale positie en omzet bij het wisselen van valuta te verhogen voor landelijk opererende banken. Verder passen we voortschrijdende coïntegratie testen toe op de termijnkoers en het agio op de termijnkoers. Vier verschillende sub-perioden kunnen aan de hand van onze coïntegratie analyse worden onderscheiden. Ten eerste is er coïntegratie vóór de financiële crisis (juli 2005 - voorjaar 2008). Ten tweede, er is geen co-integratie in de vroege stadia van de crisis (voorjaar 2008 - voorjaar 2009). Ongetwijfeld was toen de trend van de renminbi ten opzichte van de dollar zeer moeilijk te voorspellen. Ten derde, is er een coïntegratie relatie in de latere fase van de wereldwijde crisis

(voorjaar 2009 - voorjaar 2010). In deze periode is de contante wisselkoers vrijwel constant. Toen de financiële crisis zich uitbreidde, verwachtten marktpartijen blijkbaar dat de renminbi - dollarkoers zou stoppen met appreciëren. Ten vierde, is er geen coïntegratie nadat de Chinese regering haar beleid van geleidelijke appreciatie voortzette (zomer 2010 - winter 2010). Bovendien vinden we dat de "unbiased forward rate" hypothese opgeld doet in het voorjaar van 2009, toen de Chinese autoriteiten de renminbi opnieuw aan de dollar koppelden om de onrust van de wereldwijde financiële crisis te overwinnen. We concluderen dat in China de coïntegratie tussen toekomstige koersrendementen en agio op termijnkoersen in de vroege stadia van de financiële crisis ineenstortte. Echter, coïntegratie kan niet voor latere stadia van de financiële crisis afgewezen worden. Deze resultaten suggereren dat de termijnmarkt voor de renminbi inefficiënt is.